National Research Council Canada
Conseil national de recherches Canada

BIOENERGY RESEARCH AND DEVELOPMENT

A SUMMARY OF THE FEDERAL PROGRAM
APRIL 1982 TO MARCH 1983

DIVISION OF ENERGY RESEARCH AND DEVELOPMENT
OTTAWA

NRCC 21207

Canada

85-4895/

BIOENERGY RESEARCH AND DEVELOPMENT

A Summary of the Federal Program
From
April 1982 to March 1983

Compiled and Edited by

S. Hasnain
and
S.G. Dumas

of the
Bioenergy Program

Published by the Division of Energy Research and Development
of the National Research Council of Canada

Ottawa, March 1983

ACKNOWLEDGEMENT

We would like to thank all of the Scientific Authorities whose quick response in providing us with updates and information was instrumental in the production of this document.

Copies available from:

Publications
National Research Council of Canada
Building R-88
Ottawa, Ontario. K1A 0R6
Tele.: (613) 993-2054

NRCC No. 21207

THE BIOENERGY RESEARCH AND DEVELOPMENT PROGRAM 1982-1983

TABLE OF CONTENTS

Project Titles by Program Subsection

	Page
FOREWORD	1
BIOMASS RESOURCE ASSESSMENT	
Forestry - Logging Residue	
Development of a biomass model to estimate quantity of biomass following logging, in B.C. forests, to specified recovery criteria.	5
Forestry - Biomass Factors	
Data for biomass prediction equation - New Brunswick & Nova Scotia.	6
Pilot regional biomass inventory system.	7
Determination of biomass and nutrient content in trees, ground vegetation and soil of Aspen stands in Alberta.	8
Coordination of ENFOR biomass estimation projects, and development of biomass estimates based on provincial timber inventories.	9
Data collection for developing stand and single-tree biomass functions of naturally grown Eastern White Pine, Red Pine, Eastern Hemlock, Eastern White Cedar, Eastern Red Cedar and Tamarack in Ontario.	10
Stem measurement and mass data collection for 15 native hardwood species in Ontario.	11
Trial conversion of conventional inventory data to biomass data for forest types in N.B.	12
Avalon biomass inventory pilot trial.	13
Pilot study for the Canada biomass inventory.	14
Forest biomass inventory for Québec.	15
Development of biomass prediction equations for White Spruce.	16
Trial conversion of conventional inventory data to biomass data for forests in N.S.	17
Forestry - Energy Plantations - Productivity	
Hardwood coppice silviculture.	18
Agriculture - Plant Residues	
Assessment of potential for a sustained energy supply for the agriculture and food system for the Maritime region.	19
Agriculture - Energy Crops	
Assessment of Lunaria as a prospective crop for fuels and industrial oils.	20
Assessment of Milkweed as a potential renewable fuel crop.	21

Page

Agriculture - Energy Crops (cont'd)

Assessment of the potential of growing unconventional "Energy Crops" or multi-use crops on saline or marginal land. 22

Rye-corn sequences for biomass production. 23

Assessment of the agronomic, technical and economic feasibility of producing Jerusalem Artichokes for energy crop. 24

ENVIRONMENTAL EFFECTS

Forestry - Silvicultural and Harvest Impacts

Nature and extent of the impact of forest biomass harvesting on the forest environment. 27

Modelling of the long-term consequences of intensive biomass harvesting on soil fertility and biomass production. 28

Effects of harvesting biomass for energy on the nutrient status and long term productivity of selected forest sites in the Maritimes. 29

Impact of biomass production on wildlife. 30

Impact of forest biomass production on reptiles and amphibians in the Great Lakes - St. Lawrence forest region. 31

Impact of harvesting mature trees by whole-tree method on the microbiology, organic matter and nitrogen transformations of a forest soil. 32

Impact on wildlife of short-rotation management in Boreal/Aspen stands. 33

Nutrient content of various types and parts of plant samples from the forest at Petawawa National Forestry Institute. 34

SILVICULTURE

Nitrogen-fixing and mycorrhizal symbioses in forests to increase biomass production and maintain soil fertility. 37

Experimental plantations of Alnus sp. for energy. 38

Salix for biomass fuel and energy conservation. 39

Transfer of nitrogen fixing capability from Alder (Alnus) to Birch (Betula). 40

Land application of an industrial sludge to Hybrid Poplar plantations - A Lysimeter study. 41

BIOMASS PLANTING, HARVESTING AND COLLECTION TECHNOLOGIES

Field treatment system for logging residues to facilitate transportation and subsequent conversion to energy. 45

Fabrication and testing of a front-end piler. 46

Page

BIOMASS PLANTING, HARVESTING AND COLLECTION TECHNOLOGIES (cont'd)

Development of the RECUFOR and application of the RECUFOR rotor to comminution of residues at landings. 47

Soil strength measurements - evaluation study. 48

Optimization of terrain-vehicle systems in agro-forestry. 49

The design and development of a bundling attachment for poplar harvester. 50

Industrial design and consultations - harvesting equipment development. 51

Development of a singularizing device for poplar cuttings. 52

Development of a reciprocating tree cutting tool. 53

Development of a felling-bunching attachment. 54

Development of a grapple attachment and design of a front end piler attachment. 55

Design of a harvester-chipper-conveyor-storage system to harvest brushwood using the "Pallari Cutting Principle". 56

Optimization of the shearing action and pick up efficiency of the RECUFOR rotor. 57

BIOMASS CONVERSION TECHNOLOGIES

Biogas Production

Development, operation and demonstration of a farm scale anaerobic digester for production of methane from hog manure. 61

Study of the upflow, anaerobic sludge blanket reactor for methane production from food processing wastes. 62

Evaluation of downflow anaerobic fixed film reactors for methane production from wastes. 63

Development of advanced anaerobic treatment technologies for the production of methane from waste. 64

Anaerobic digester mixing study. 65

Upgrading waste biomass into methane fuel gas by anaerobic fermentation. 66

Feasibility assessment of biogas generation by anaerobic fermentation of pulp and paper wastes. 67

Demonstration of fixed film anaerobic reactor. 68

Mobile anaerobic fixed-film reactor. 69

Anaerobic digestion control equipment. 70

Improving production and reliability of methane digesters. 71

Design, fabrication and monitoring of a complete anaerobic hog waste treatment system with energy recovery. 72

Page

Biogas Production (cont'd)

The design of a digester for pig manure. 73

Biological process application for biogas production and waste treatment. 74

Development of computer control system for anaerobic reactors. 75

Anaerobic fixed film development and performance. 76

Fermentation to Alcohol

Conversion of cellulose to ethanol using a two stage process. 77

Liquid fuel production from hemicellulose. 78

Development of an economical fermentation process for the production of organic solvents from biomass. 79

Evaluation of D-xylose fermenting yeasts on wood hydrolysates. 80

Production of alcohol from spent sulfite liquor using NRC pentose fermenting yeast. 81

Development of low cost process for ethanol recovery. 82

Comparison of free and immobilized cell fermentation to fuel alcohol. 83

Characterization of a pilot scale adsorbed cell bioreactor for ethanol production. 84

Development of a system for automatically denaturing ethanol destined for fuel pruposes. 85

Assessment of the production of alcohol in two phase systems. 86

Process engineering of solvent extraction coupled fermentations for product recovery. 87

Development of film reactors applicable to ethanol production. 88

Development of a flexible farm-scale fuel alcohol production system. 89

Fuel ethanol dehydration. 90

Development of a system of automatically denaturing ethanol destined for fuel purposes. 91

Ethanol from cellulosics pilot plant. 92

Low Joule Gasification

A kinetic and catalytic study for the optimization of the fluidized bed gasification process. 93

Development of analytical methodology for biomass gasification products. 94

Development, operation and evaluation of a small scale gasification/water heating system. 95

Data collection for downdraft wood gasifier operation. 96

Page

Medium Joule Gasification

Development and demonstration of a pressurized oxygen fluidized bed for wood gasification. 97

Molten salt technology for wood to syngas conversion. 98

Development of a simple dual-bed fluidized gasifier for biomass and other pyrolyzable wastes. 99

Methanol

Improved alcohol synthesis through periodic operation. 100

Direct Combustion

Demonstration and testing of a "Lamb" wet-cell burner using hogged wood waste for firing a pulp mill lime kiln. 101

Advanced feedstock preparation system for large-scale hog fuel boilers. 102

Coordination of the test program on boilers burning wood refuse. 103

Test program on boilers burning wood refuse. 104

Effect of particle size on the gross heat of combustion of wood. 105

Evaluate canola oil as a fuel for farm diesel engines. 106

Conversion of oil/gas heating plant to biomass fueled plant. 107

Study of the catalytic esterification of canola oil for farm diesel engines. 108

Oil Production - Liquefaction

Liquid fuels and chemicals from Aspen. 109

Characterization of the pyrolytic oils from Trembling Aspens. 110

Production of oils from wood. 111

Processes for the conversion of wood to liquid fuels and chemicals through a continuous/semi-continuous liquefaction unit. 112

Chemical characterization of wood conversion to liquid fuels. 113

Chemical Feedstocks

Supercritical gas extraction of chemicals from forest products. 114

Pyrolysis

High intensity pyrolysis of biomass. 115

Continuous flash pyrolysis of wood. 116

An investigation of the fast pyrolysis of wood and its components using the ultrapyrolysis process. 117

Study of liquid fuels from the flash pyrolysis of agricultural biomass. 118

Economic evaluation of the gas yields from a plasma pyrolysis gasification system using wood-based fuels. 119

Page

Pyrolysis (cont'd)

Detailed design, construction and operation of a vacuum pyrolysis process development unit (PDU). 120

Electrical discharge flash pyrolysis of biomass. 121

Ultrafast pyrolysis (Ultrapyrolysis) of heavy oils and solid fuels. 122

BIOENERGY - STRATEGIC STUDIES

Anaerobic Fermentation

Anaerobic conversion of cellulose to methane. 125

Anaerobic production of fuels, chemicals, cellulolytic enzymes and sugars from cellulosic biomass. 126

Acetone-butanol fermentation. 127

Fermentation of Pentoses

Fermentation of pentoses by yeasts. 128

High yield pentose fermenting yeasts for immobilized cell bioreactors. 129

Two stage process for conversion of xylose to ethanol. 130

Genetic Manipulation of Microbial Strains for Energy Production

The construction of microbial strains for energy production. 131

Novel technology for alcohol production by fermentation. 132

Development of an amylase producing yeast. 133

To produce new strains of yeast via genetic engineering for direct conversion of cellulose to alcohol. 134

Cloning and expression of cellulase genes. 135

Molecular Models of Photosynthesis

A study of organic phtotovoltaic cells based on photosynthesis pigments. 136

Membrane Applications in Gas and Liquid Separations

Membrane application in gas and liquid separations. 137

Oil-Bearing Microbes

Oil-bearing microbes: microbial systems for liquid fuels. 138

Hydrocarbon production from algal and fungal biomass. 139

Immobilized Cell Techniques for Fuel Production

Continuous ethanol production using immobilized cells of Zymomonas mobilis. 140

Immobilized systems in biotechnological processes. 141

Page

Cellulase

Solid-state fermentation of poplar wood. 142

Regulation of cellulase production in industrially important microorganisms. 143

Aerobic production of fuels, chemicals, cellulolytic enzymes and sugars from wood cellulose. 144

Bioconversion of lignocellulosics by Streptomyces flavogriseus. 145

SOCIO-ECONOMIC-TECHNICAL STUDIES

Technology Assessment

Forest product based sacrificial agents for enhanced oil recovery. 149

Technical assessment of downdraft gasifiers. 150

Uniformity of product of Iotech's steam explosion pretreatment. 151

Analysis of wood chips and Iotech steam exploded wood. 152

Assessment of Iotech steam exploded wood. 153

Update of wood liquefaction technology. 154

Analysis of Iotech steam exploded wood. 155

Evaluation of approaches to the hydrolysis of lignocellulosics from Canadian hardwoods. 156

Evaluation of an anaerobic digester. 157

Comparison of enzymatic and acid hydrolysis and fermentation methods of steam treated lignocellulosic agricultural residues. 158

Technical/economic study of farm and industrial scale fuel ethanol plant employing vapour compression distillation. 159

Study for the evaluation of a single stage continuous airlift fermenter. 160

Economic Assessment

Operating and developing a computer model for wood to ethanol. 161

Comparison study in harvesting forest biomass as an alternative fuel. 162

Evaluation of the productivity and costs of harvesting wet-belt Cedar and Hemlock biomass. 163

Development of an integrated operation for Aspen wood products and energy from Aspen. 164

Information

Opportunities for using forest biomass for energy in Québec. 165

Comparative assessment of forest biomass conversion to energy forms. 166

Review of the ENFOR production program. 167

Page

BIOMASS MATERIALS HANDLING, TRANSPORTATION & PRE-TREATMENT

Materials Handling

Bin and silo design for biomass materials. 171

Fuel value of stored forest/mill residues. 172

A study of the forces exerted by hog fuel piles on restraining structures. 173

Development of a feed mechanism for straw burners. 174

Development of a dense phase pneumatic conveying system for biomass materials. 175

Pre-treatment

To perform a study of hog fuel drying using vapour recompression. 176

A study of the pretreatment preparation of forest biomass as feedstock for bioconversion processes. 177

Design, fabrication and testing of a prototype log splitter. 178

Pretreatment methods for enhancing conversion of lignocellulosic materials to liquid fuels. 179

Assessment of wet oxidation of agricultural residues to form fermentation substrates. 180

Microbial fractionation of native biomass to lignin, celulose and hemicellulose. 181

Saccharification of biomass by reduced pressure pyrolysis followed by hydrolysis. 182

Evaluation of a one stage continuous acid hydrolysis process for conversion of agricultural materials into sugars. 183

Use of extrusion in the conversion of agricultural biomass to fuel alcohol. 184

Biomass feedstocks from poplar wood using supercritical fluids. 185

Preparation of wood for combustion. 186

BIOENERGY PROJECT MANAGEMENT

Project management in support of ENFOR. 189

Bioenergy program management. 190

APPENDIX I

Resource allocation in Bioenergy R&D from 1977 to 1982 inclusive. Source of funding of Bioenergy R&D in 1982-83. 193

APPENDIX II

Classification index. 194

Page

APPENDIX III

Report availability. 196

APPENDIX IV

Bioenergy R&D report listing. 197

APPENDIX V

Index of investigators. 213

APPENDIX VI

Index of organizations. 218

FOREWORD

We present here a compilation of all bioenergy research and development sponsored by agencies and ministries of the Canadian Government from April 1982 through March 1983.

THE PROGRAM

Federally sponsored Bioenergy Research & Development is a multi-faceted activity involving the National Research Council, the Natural Sciences & Engineering Research Council and Departments of Environment, Agriculture and Energy, Mines & Resources. The work is conducted by federal scientists working within government laboratories, private contractors, and university scientists. The lead agency for Bioenergy Research & Development is the National Research Council which manages and coordinates the activities within the Federal laboratories and the contracted programs. The major contract research program (Energy From the Forest or ENFOR) is managed by the Canadian Forestry Service of Environment Canada.

The research which results from the strategic grants awarded to university scientists is managed solely by the Natural Sciences & Engineering Research Council. The inclusion of these projects in this publication has been done to present a complete overview of the federal effort in Bioenergy Research & Development activities.

The history of Bioenergy Research & Development can be viewed in financial terms through a perusal of Appendix I.

The Bioenergy Program fits within the research and development activities of the National Energy Program which is comprised of six task areas; namely, conservation; oil sands/heavy oil, coal supply and combustion; nuclear energy; renewable energy; new liquid fuels and; conventional energy systems of oil, gas, electricity. From the inception of the contract research program in 1977 through fiscal year 1981 funding was received solely through the renewable energy task of the interdepartmental panel on energy research and development. However, commencing with fiscal year 1982 parts of the program were identified as having the objective of production of a liquid fuel and, therefore, were fitted within a new task called New Liquid Fuels, which paralleled one of the priority objectives of the National Energy Program. Those bioenergy projects funded by the Liquid Fuels Task are identified as such and similarily projects funded by NSERC have been identified.

Further information on the scope and operation of the program is available from the Bioenergy Program Office, Division of Energy Research & Development, National Research Council, Suite 381, Building M-55, Montreal Road, Ottawa, Canada K1A OR6. Telephone: (613) 993-1342. Telex: 053-3115.

THIS PUBLICATION

The Bioenergy program is divided into ten subprograms each of which has a number of areas of priority concern. This structure is given in detail in Appendix II. Projects are grouped according to the organization of the program. The information on the one-page Project Data Sheet represents the status of the project as known to us at the time of going to print. Information developments since that time can be obtained by contacting the Scientific Authority whose name and address is given on the project data sheet. For detailed information contained in reports emanating from the research projects, refer to Page 196 on which is contained a description on how to obtain reports issued by the various sponsoring organizations. For those users who are interested in determining the level of involvement in the program by a particular organization, Appendix VI lists these organizations alphabetically for easy reference. Additionally, for each project one person in the research organization is named as principal investigator, project leader or responsible scientist and these people are included in Appendix V again in alphabetical order for easy reference to their project responsibilities.

We hope this publication provides you with an appreciation for the level of activity in Bioenergy Research & Development in Canada and leads you to additional sources of information in your particular field of interest.

BIOMASS RESOURCE ASSESSMENT

Forestry - Mill Wastes

Forestry - Logging Residue

Forestry - Biomass Factors

Forestry - Energy Plantations - Productivity

Agriculture - Animal Residues

Agriculture - Plant Residues

Agriculture - Energy Crops

Peat

Algae

PROJECT DATA SHEET # 141

TITLE	Development of a Biomass Model to Estimate Quantity of Biomass Following Logging, in B.C. Forests, to Specified Recovery Criteria	**PROGRAM IDENTIFICATION**	4.3.1.2 Biomass Resource Assessment/ Forestry-Logging Residue
		DURATION	April 1980-March 1983
		COST	$416,000
CONTRACT #	KL017-9-655 (0S880-1) P-142	**SPONSOR**	Environment Canada
CONTRACTOR	Talisman Projects Incorporated 842 Thurlow Street, 3rd Floor Vancouver, B.C. V6E 1W2	**SCIENTIFIC AUTHORITY**	G.H. Manning Pacific Forest Research Centre Canadian Forestry Service 506 West Burnside Road Victoria, B.C. V8Z 1M5
PRINCIPAL INVESTIGATOR	D.E. Shroeter		

OBJECTIVE

1. To develop a system for estimating biomass per ha (total and component parts) as a function of designated recovery criteria, thereby enabling an investigation of optimum harvesting plans balancing biomass production with production of conventional forest products.
2. To develop this system where possible around existing B.C. Ministry of Forests inventory data and procedures.
3. To develop, as a necessary part of this system, improved individual tree component biomass relationships.

DESCRIPTION

Proposed Approach: The consultant will choose a sample of 1,000 trees in B.C., well distributed by species, site range, and diameter class, where possible in cooperation with the B.C. Ministry of Forests. The trees will be measured, felled, weighed and sampled for moisture content. Biomass weight equations will be prepared by component and species. He will gather, from Ministry sources, appropriate information on proportion of biomass in non-commercial trees, waste and breakage data, and merchantable volume factors. He will integrate these data into a simulation model which will predict, for any level of commercial utilization, the residue which will remain after logging; and he will test said model under actual conditions.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1980-81	$ 85,000			$ 85,000
1981-82	$160,000			$245,000
1982-83	$170,000		$ 1,000	$416,000

REPORTS

STATUS AND COMMENTS

83/03/06

PROJECT DATA SHEET # 143

TITLE	Data for Biomass Prediction Equation - N.B. and N.S.	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Forestry - Biomass Factors
CONTRACT #	KL003-0-0007 (OSC80-3) P-159	**DURATION**	April 1980-March 1983
		COST	$257,500
CONTRACTOR	Woodlot Service Limited 320 Maple Street Fredericton, N.B.	**SPONSOR**	Environment Canada
PRINCIPAL INVESTIGATOR	G.B. Young	**SCIENTIFIC AUTHORITY**	G.D. van Raalte Maritimes Forest Research Centre Canadian Forestry Service P.O. Box 4000 Fredericton, N.B. E3B 5P7

OBJECTIVE

To determine green weights for whole and component parts of balsam fir, red/black spruce, white spruce, jack pine, red maple, aspen and white birch.

DESCRIPTION

Some 1400 individual trees will be selected from 200 random sample areas in New Brunswick (120) and Nova Scotia (80). These areas will be selected by M.F.R.C. From each sample area, 1 tree of each of the 7 species mentioned above will be selected, and its height, diameter, and crown dimensions measured. Each tree will then be processed in a standard manner prescribed by M.F.R.C. Appropriate samples will be removed from all above-ground parts of the tree (stem, branches, foliage, etc.) and transported to Fredericton for further processing.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1980-81	$80,000			$ 80,000
1981-82	$89,000			$169,000
1982-83	$80,000		$ 8,500	$257,500

REPORTS

STATUS AND COMMENTS

All field work completed. All laboratory work completed. Final report will be available May 1983. G.D.VR

83/04/14

PROJECT DATA SHEET # 205

TITLE	Pilot Regional Biomass Inventory System	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Forestry Biomass Factors
CONTRACT #	KL015-0-0102 (0SS80-139) P-148	**DURATION**	April 1980 - March 1983
CONTRACTOR	Systemhouse 2827 Riverside Drive Ottawa, Ontario K1V 0C4	**COST**	$246,501
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	C.L. Kirby Northern Forest Research Centre Canadian Forestry Service 5320-122nd Street Edmonton, Alberta T6H 3S5

OBJECTIVE

1. To provide pilot study of a computerized interactive information system for biomass inventories suitable for provincial needs and compatible with national resource data systems.
2. To provide an in-house biomass data base to be used for regional and national requirements.
3. To demonstrate the usefulness of Landsat and large-scale photo sampling in a multi-stage sampling design for estimating biomass.

DESCRIPTION

A total of one million hectare data base for Alberta, Saskatchewan, Manitoba, and the Northwest Territories will be developed using the forest inventory data obtained from Alberta and Saskatchewan, Landsat imagery, large-scale photo samples and regional biomass prediction equations. Thus, the biomass of various forest covertypes will be estimated through a computerized system whose output and format will be sufficiently flexible to satisfy resource management goals for timber, wildlife, recreation, and water. The data base will be compatible with that proposed by the Canadian Forestry Service.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$108,516			$108,516
1981-82	$ 65,985			$174,501
1982-83	$ 72,000			$246,501

REPORTS

KIRBY C.L., CHOW W., Mapping and Resouce Analysis System. (MARS) Northern Forest Research Centre (Paper for the annual meeting of Canadian Inst. of Surveying, April 1982).

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 213

TITLE	Determination of Biomass and Nutrient Content in Trees, Ground Vegetation and Soil of Aspen Stands in Alberta	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Forestry - Biomass Factors
CONTRACT #	KL015-1-0012 (0SS81-00114) P-205	**DURATION**	August 1981 - March 1984
		COST	$417,711
		SPONSOR	Environment Canada
CONTRACTOR	Alan Moss & Associates Ltd. 1334 St. Paul Street Kelowna, B.C. V1Y 2E1	**SCIENTIFIC AUTHORITY**	L.G. Brace Northern Forest Research Centre Canadian Forestry Service 5320-122 Street Edmonton, Alberta T6H 3S5 Tel.: 435-7210
PRINCIPAL INVESTIGATOR		**TECHNICAL LIAISON OFFICER**	I.K. Edwards Northern Forest Research Centre Edmonton, Alberta T6H 3S5

OBJECTIVE

The major objective of this project is to determine biomass and nutrient content of trees, understory vegetation, forest floor and mineral soil within aspen stands of the mixedwood region. These data (along with tree data being collected) will be necessary to assess fully the effect of whole tree removal on the nutrient budget within this type of forest ecosystem. The latter information will be useful in assessing the availability of soil nutrients for the succeeding tree crop

DESCRIPTION

Field work will consist of identification and sampling description of representative aspen stands of fire origin in Alberta. There will be 36 plots, 12 for each of 3 age classes, ranging from 15 to 45 years, on a medium site.

There will be 5 tree samples per plot to cover the diameter range by 5 groupings. This will give a total sample of 180 aspen trees. Each stand sampled will be at least 95% hardwood, primarily aspen, and confined to a single clone.

Field sampling must be restricted to the time period July 15 to September 15 to minimize fluctuations in nutrient concentration of tree components in the sample.

Tree sampling will follow the procedure used in ENFOR Project P-92, with the addition of root information. Components sampled will therefore be stump, roots, merchantable and non-merchantable stem, branches, and foliage. Ground vegetation will be sampled also. Wood, branches, roots, foliage and ground vegetation will be analyzed for N, P, K, Ca, Mg and S.

At each plot, samples of the forest floor and each of 3 horizons of mineral soil will be sampled. These will be analyzed for pH, electrical conductivity, texture, bulk density, organic matter, N, P, K, Ca, Mg, S, and available water capacity. This data will be used to determine biomass and nutrient content on an area basis.

Data sufficient to compute stem wood volume & crown & root mass for each tree sample, following ENFOR P-92 procedures, will be taken. Forms for these data will be supplied.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$ 41,827			$ 41,827
1982-83	$301,386		$ 17,000	$360,213
1983-84	$ 57,498			$417,711

REPORTS

Final draft report due August 31, 1983.

STATUS AND COMMENTS

Laboratory analysis on schedule. Vegetation analysis complete. Soils completed by April 1983.

83/04/26

PROJECT DATA SHEET # 225

TITLE	Coordination of ENFOR Biomass Estimation Projects, and Development of Biomass Estimates based on Provincial Timber Inventories	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Forestry-Biomass Factors
		DURATION	July 1981 - March 1983
CONTRACT #	KL229-1-4260 (0SS81-00092) P-227	**COST**	$183,777
		SPONSOR	Environment Canada
CONTRACTOR	T.M. Thomson & Assoc. Ltd. 1006 Government Street Victoria, B.C. V8W 1X7	**SCIENTIFIC AUTHORITY**	M.R. Keen Forest Statistics and Systems Branch Environment Canada Chalk River, Ontario K0J 1J0
PRINCIPAL INVESTIGATOR	W.A. Hopwood		

OBJECTIVE

To coordinate the development of biomass estimation equations, and their application on the forest inventory data of all provinces in order to generate forest biomass estimates according to specifications of the Canadian Forest Resource Data System.

DESCRIPTION

1. Review biomass estimation project proposals and make recommendations for support.
2. Coordinate biomass estimation projects within the CFS by maintaining liaison with regional establishments, and by monitoring progress in developing and testing procedures to convert timber inventories to biomass estimates.
3. Develop minimum criteria for biomass inventories and methods for inventory conversion to mass estimates.
4. Plan and facilitate biomass pilot projects with the Canadian Forest Resource Data System.
5. Establish national and regional data bases for the storage of biomass data gathered on ENFOR projects.
6. Prepare comprehensive reports on work accomplished, and document field and office (software) procedures.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 84,000			$ 84,000
1982-83	$ 99,777			$183,777

REPORTS

STATUS AND COMMENTS

For previous work refer to project data sheet 208 (P-2I9) 83/03/04

PROJECT DATA SHEET # 280

TITLE	Data Collection for Developing Stand & Single-tree Biomass Functions for Naturally Grown Eastern White Pine, Red Pine, Eastern Hemlock, Eastern White Cedar, Eastern Red Cedar & Tamarack in Ontario	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Forestry - Biomass Factors
		DURATION	2 years
		COST	$100,602
CONTRACT #	KL011-1-257 (OSS81-80) P-179	**SPONSOR**	Environment Canada
CONTRACTOR	Horton Forestry Service Limited R.R. #4 Stouffville, Ontario L0H 1L0	**SCIENTIFIC AUTHORITY**	I.S. Alemdag National Forestry Inst. Canadian Forestry Service Environment Canada Chalk River, Ontario K0J 1J0 Tel.: (613) 589-2880
PRINCIPAL INVESTIGATOR	Keith W. Horton		

OBJECTIVE

To collect stand and tree biomass data to enable the PNFI staff to develop stand and tree mass functions and relationships.

DESCRIPTION

The contract will cover establishing and measuring 95 sample plots (each containing 2 sub-plots), felling and measuring 600 sample trees in the field, and processing sample material at the laboratory. The sample plots will be established in pure or mixed and not severely disturbed (fire, insect, diseases) stands of the species to be studied, selected throughout their Ontario range, on a variety of sites, and not simply for one or two localities. The sample trees will be taken within the sample plots from trees of average health and vigor, and with unbroken tops. The sample trees will cover the range of diameter at breast height outside bark (dbhob) of each of these species in Ontario, starting from 0.1 cm. While selecting the sample trees, particular attention will be paid to including an even distribution of trees by dbhob classes and to including the full range of the height distribution in each of the classes. Extreme sizes can be taken from outside the sample plot or without establishing a sample plot. While taking the sample trees of one species from a sample plot established in a mixed stand, sample trees of the other contract species could also be taken if it is found to be convenient. In addition to these sample trees, 30 shrubs (under 1.30 cm height) from each species, will be taken.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$60,000			$ 60,000
1982-83	$38,602		$ 2,000	$100,602

REPORTS

Biomass Equations are Merchantable Factors for Ontario Softwoods (Under review for publication), 1983.

STATUS AND COMMENTS

Data collection was completed in 1982, the data were evaluated, and the project was terminated. I.S.A.

83/04/27

PROJECT DATA SHEET # 296

TITLE Stem Measurement & Mass Data Collection for 15 Native Hardwood Species in Ontario

CONTRACT # KH415-2-0029 (0SS82-00038)
P-234

CONTRACTOR Dendron Resource Surveys Ltd.
P.O. Box 6493
Postal Station 'J'
Ottawa, Ontario
K2A 3Y6

PRINCIPAL INVESTIGATOR V. Nielsen

PROGRAM IDENTIFICATION 4.3.1.3
Biomass Resource Assessment/ Forestry - Biomass Factors

DURATION June 8, 1982
to March 31, 1984

COST $186,275

SPONSOR Environment Canada

SCIENTIFIC AUTHORITY I.S. Alemdag
Petawawa National Forestry Institute
Canadian Forestry Service
Environment Canada
Chalk River, Ontario
K0J 1J0

Tel.: (613) 589-2880

OBJECTIVES

To collect and process biomass data on hardwood species in Ontario in order to develop biomass equations and establish biomass/volume relationships.

DESCRIPTION

The contract will include felling and measuring 1140 sample trees in the field, and processing sample material at the laboratory. The sample trees will be taken in pure or mixed and not severely disturbed (fire, insect, diseases, logged) stands of the species to be studied. These trees will be of at least average health and vigor, and with unbroken tops and undeformed stems. The sample trees will cover the range of diameter at breast height outside bark (dbhob) of each of these species, starting from 0.1 cm. While selecting the sample trees, particular attention will be paid to including the full range of the height (h) distribution in each of the diameter classes. In addition to these sample trees, 10-15 seedlings under 1.30 m height from each species, will be taken. Also, some dead trees will be sampled from all species including various tree sizes.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$120,000		$ 2,000	$122,000
1983-84	$ 64,275			$186,275

REPORTS

STATUS AND COMMENTS

Collection of the data in 1982 on six tree species is complete. Data on the remaining species will be collected in 1983. I.S.A.

83/04/27

PROJECT DATA SHEET # 297

TITLE Trial Conversion of Conventional Inventory Data to Biomass Data for Forest Types in N.B.

CONTRACT # KH209-2-0121 (OSC82-00141)
P-238

CONTRACTOR New Brunswick Department of Natural Resources
212 Queen Street
P.O. Box 6000
Fredericton, N.B.
E3B 5H1

PRINCIPAL INVESTIGATOR

PROGRAM IDENTIFICATION 4.3.1.3
Biomass Resource Assessment/ Forestry - Biomass Factors

DURATION June 23, 1982 to February 23, 1983

COST $25,500

SPONSOR Environment Canada

SCIENTIFIC AUTHORITY
G.D. van Raalte
Maritimes Forest Research Centre
Environment Canada
Canadian Forestry Service
P.O. Box 4000
Fredericton, N.B.
E3B 5P7
Tel.: (506) 452-3519

OBJECTIVE

1) To develop techniques and demonstrate the conversion of conventional forest inventory data to biomass inventory data.
2) To estimate time and cost to implement methods and techniques developed in (1) for province wide conversion.

DESCRIPTION

Present forest inventory in New Brunswick is in conventional terms - merchantable volume for merchantable species. The first logical step towards a total biomass inventory is the conversion of the present conventional inventory to a biomass one. Biomass equations already developed by MFRC (P-4, P-38, P-159) will be used to convert selected areas of the existing provincial inventory from volume to weight. Methodology, time, costs and missing data will be detailed to facilitate province wide conversion in 1983/84.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$25,000		$ 500	$25,500

REPORTS

Contractors report will be published in May 1983.

STATUS AND COMMENTS

Contract near completion. G.D.VR 03/83 83/04/27

PROJECT DATA SHEET # 298

TITLE	Avalon Biomass Inventory Pilot Trial	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Forestry - Biomass Factors
CONTRACT #	KH205-1-0126 (OSC82-00031) P-240	**DURATION**	May 6, 1982 to September 15, 1982
CONTRACTOR	Northland Associates Ltd. 13 Prescott Street P.O. Box 1734 St. John's, Newfoundland A1C 5P5	**COST**	$43,000
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	R.S. van Nostrand Newfoundland Forest Research Centre Environment Canada Bldg. 304, Pleasantville St. John's, Newfoundland A1C 5X8 Tel.: (709) 772-4806

OBJECTIVE

To test and refine methods for conducting a complete forest biomass inventory.

DESCRIPTION

Phase 1 Survey crews will collect the traditional tree and stand data, plus the data on trees and shrubs below 9 cm d.b.h. required for the biomass inventory.

Phase 2 This phase is a continuation of services to establish temporary sample plots and collect data from the non-commercial forest not sampled by the NDFRL.

Approximately 100 temporary sample plots will be randomly located in four categories of non-commercial forest on the Avalon Peninsula, distributed as follows:

Softwood scrub	- 40 plots
Hardwood scrub	- 20 plots
* NSRV	- 20 plots
Stands 0-20 yrs of age	- 20 plots

* Land not sufficiently restocked due to vegetation.

Plots will be circular with a radius of 2.825 m (area, 25 m^2).

Trees 9 cm+ d.b.h. will be recorded by species, and diameter measured to the nearest tenth of a centimetre. Height will be estimated to the nearest metre. Trees and shrubs less than 9.0 cm d.b.h. will be recordec by species and 2 cm diameter classes (1-2.9 cm, 3.0-4.9 cm, 5.0-6.9 cm, and 7.0-8.9 cm). Average height by species and diameter class will be estimated to the nearest metre.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$40,000		$ 3,000	$43,000

REPORTS

Northland Associates Ltd., Avalon Biomass Inventory Pilot Trial. 1982, Contractor's Report

STATUS AND COMMENTS

Project completed. R.S.VN

83/04/27

PROJECT DATA SHEET # 299

TITLE	Pilot Study for the Canada Biomass Inventory	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Forestry - Biomass Factors
CONTRACT #	KH415-2-0215 (OSS82-00044) P-242	**DURATION**	June 16, '82 - March 31, '83
		COST	$369,000
CONTRACTOR	Forestry Statistics and Systems Branch Canadian Forestry Service Chalk River, Ontario K0J 1J0	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	G.M. Bonnor Canadian Forestry Service Chalk River, Ontario K0J 1J0 Tel.: (613) 589-2280
PRINCIPAL INVESTIGATOR		**TECHNICAL LIAISON OFFICER**	R.S. van Nostrand Newfoundland Forest Research Centre P.O. Box 6028 St. John's, Nfld. A1C 5X8 Tel.: (704) 772-4804

OBJECTIVE

To develop and implement methodology for estimation of forest biomass from provincial forest inventories.

DESCRIPTION

Tree biomass equations are applied - in replacement of tree volume equations - to provincial sample plot data. From the resulting data, biomass stand and stock tables are calculated. These are then applied to existing area data, and biomass totals, by species and components, are calculated.

Additional data, from forest areas not included in the timber inventory, are obtained. All data are converted and loaded into the national data base maintained by the CFS, and tabular summaries and maps are produced.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$356,000		$ 13,000	$369,000

REPORTS

Pilot Study for the Canada Biomass Inventory. September 1982

STATUS AND COMMENTS

Project completed on schedule. About 18 sub-contractors and agencies participated in the pilot study. G.M.B. 83/04/27

PROJECT DATA SHEET # 301

TITLE	Forest Biomass Inventory for Québec	**PROGRAM IDENTIFICATION**	4.3.1.3 Biomass Resource Assessment/ Biomass Factors
CONTRACT #	KM303-2-C-013 (OSD82-00049) P-236	**DURATION**	June 22, 1982 to October 29, 1982
CONTRACTOR	Blais, McNeil, Lussier & Assoc. 3083 Quatre-Bourgeois Ste-Foy, Québec G1W 2K6	**COST**	$137,235
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	Yvon Lussier Tel.: (418) 653-2652	**SCIENTIFIC AUTHORITY**	Denis Ouellet Environment Canada Canadian Forestry Service 1080 du Vallon P.O. Box 3800 Ste-Foy, Québec G1V 4C7 Tel.: (418) 653-6842

OBJECTIVES

The main objective is to establish regression equations to permit the calculation of the mass of the different parts of a tree starting from conventional parameters such as diameter and total height. The twelve most important commercial species in Québec are included.

DESCRIPTION

Grids are to be set up in public forests in Québec according to specified details. The location of these grids is to be based on selecting a variety of populations including pure and mixed stands.

Essential criteria are to be determined in detail for individual trees and for their components to allow a comprehensive inventory of each tree. The work is to include the detailed recording of all the appropriate measurements of mass, height, diameter, etc. for selected trees in the study. Each selected tree is to be felled, delimbed and measurements and samples taken from all parts of the tree according to a specified plan. Samples will be sent to the laboratory where they will be dried and reweighed for each component part including leaves.

Using the above data tree component weights are to be calculated and regression equations established.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$125,235		$ 12,000	$137,235

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 302

TITLE Development of Biomass Prediction Equations for White Spruce

CONTRACT # KH603-2-0020 (OSB82-00102)
P-246

CONTRACTOR Nawitka Renewable Resources Consultants Ltd.
836-840 Cormorant Street
Victoria, B.C.
V8W 1R1

PRINCIPAL INVESTIGATOR

PROGRAM IDENTIFICATION 4.3.1.3
Biomass Resource Assessment/ Biomass Factors

DURATION May 25, 1982
to March 31, 1983

COST $92,877

SPONSOR Environment Canada

SCIENTIFIC AUTHORITY
G.H. Manning
Program Manager
Pacific Forest Research Centre
Canadian Forestry Service
506 West Burnside Road
Victoria, B.C.
V8Z 1M5
Tel.: 338-3811

OBJECTIVE

The main objective is to establish regression equations to permit the calculation of the mass of the different parts of a tree starting from conventional parameters such as diameter and total height.

DESCRIPTION

The work is to include the detailed recording of all the appropriate measurements of mass, volume, diameter, etc. for selected trees in the study. This is to include geographical and ecological data. Each selected tree is to be felled, delimbed and measurements and samples taken from all parts of the tree according to a specified plan.

Samples will be sent to the laboratory where they will be dried and reweighed for each component part including leaves.

Using the above data and the ratios for gw/odw, bark/wood, foliage/wood, tree component weights are to be calculated and regression equations established.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$89,877		$ 3,000	$92,877

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 303

TITLE Trial Conversion of Conventional Inventory Data to Biomass Data for Forests in N.S.

CONTRACT # KH209-2-0122 (OSC82-00160)
P-247

CONTRACTOR Nova Scotia Department of Lands and Forests
P.O. Box 68
Truro, Nova Scotia
B2N 5B8

PRINCIPAL INVESTIGATOR

PROGRAM IDENTIFICATION 4.3.1.3
Biomass Resource Assessment/ Biomass Factors

DURATION July 12, 1982
to February 23, 1983

COST $26,000

SPONSOR Environment Canada

SCIENTIFIC AUTHORITY
G.D. van Raalte
Maritimes Forest Research Centre
Environment Canada
Canadian Forestry Service
P.O. Box 4000
Fredericton, New Brunswick
E3B 5P7
Tel.: (506) 452-3519

OBJECTIVE

1) To develop techniques and demonstrate the conversion of conventional forest inventory data to biomass inventory data.
2) To estimate time and costs to implement methods and techniques developed in 1) for province wide conversion.

DESCRIPTION

Present forest inventory in N.S. in conventional terms - merchantable volume for merchantable species. The first logical step towards a total biomass inventory is the conversion of the present conventional inventory to a biomass one. Biomass equations already developed by MFRC (P-4, P-38, P-159) will be used to convert selected parts of the existing provincial inventories from volume to weight. Methodology, time, cost and missing data will be detailed to facilitate province wide conversion in 1983/84.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$25,000		$ 1,000	$26,000

REPORTS

Contractors report will be published in May 1983.

STATUS AND COMMENTS

Contract completed March 1983. G.D.VR

83/04/27

PROJECT DATA SHEET # 206

TITLE	Hardwood Coppice Silviculture	**PROGRAM IDENTIFICATION**	4.3.1.4 Biomass Resource Assessment/ Forestry-Energy Plantations-Productivity
CONTRACT #	KL004-0-C016 (05080-47) P-154	**DURATION**	3 years
CONTRACTOR	Perreault et Associés 376 du Roi, bureau 307 Québec, Québec G1X 2W6	**COST**	$59,000
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	A. Perreault Tel.: (418) 525-4971	**SCIENTIFIC AUTHORITY**	Gilles Frisque Laurentian Forest Research Centre Canadian Forestry Service 1080, route du Vallon Ste-Foy, Québec Tel.: (418) 653-2143

OBJECTIVE

1. To test methods and concepts of coppice management and silviculture of existing hardwood stands.
2. To study the potential and feasibility of producing biomass for energy through coppicing.

DESCRIPTION

Using existing stands, the above-ground biomass obtained through coppicing will be calculated using various harvesting methods, and species growing on different soils. Natural densities will be determined so that the ideal density can be identified once the artificially increased densities are known in the 2nd year of the project.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1980-81	$32,000			$32,000
1981-82	$15,000			$47,000
1982-83	$11,000		$ 1,000	$59,000

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 310

TITLE Assessment of Potential for a Sustained Energy Supply for the Agriculture & Food System for the Maritime Region

CONTRACT # 01843-1-ER09 (OSZ81-00141)

CONTRACTOR
Technical University of Nova Scotia
Centre for Energy Studies
P.O. Box 1000
1360 Barrington Street
Halifax, Nova Scotia
B3J 2X4

PRINCIPAL INVESTIGATOR D. Procos

PROGRAM IDENTIFICATION 4.3.1.6
Biomass Resource Assessment/ Agriculture - Plant Residues

DURATION February 22, 1982 to July 31, 1982

COST $30,656

SPONSOR Agriculture Canada

SCIENTIFIC AUTHORITY
H.T.M. Colwell
Energy Analysis and Policy Division
Regional Development and International Affairs Branch
Agriculture Canada
Sir John Carling Building
Ottawa, Ontario K1A 0C6
Tel.: (613) 995-9554

OBJECTIVE

The objective is to assess the potential for a sustained energy supply from the agriculture and food system in the Maritimes by: developing a highly disaggregated inventory of agri-food system based energy feestocks; evaluating feedstocks and end product energy forms; evaluating the economics of energy supply; identifying the realistic potential for regionally-based energy supply from the agri-food system; identifying and assessing constraints limiting attainment of the potential.

DESCRIPTION

Energy supply resources to be evaluated should include:
- crop residues, culls, wastes (food processing and animal), energy crops.

A highly disaggregated study is required because some feedstock sources may be site or area specific. Existing data sources on land used for food and feed purposes e.g. Census data, provincial agricultural statistics, farm and agricultural enumerative surveys will have to be supplemented by sources indicating data on land not used for feed and food purposes such as the Canadian Land Inventory.

Economic factors to be assessed for individual regions, and feedstock resources could include:
- value of energy feedstock in current use
- suitability of feedstock for various energy conversion routes
- extra non-feedstock resources (in physical and financial terms) required to bring each potential energy feedstock into energy production
- energy supply potential and cost estimates up to point of utilization under conversion routes and unit input cost assumptions

Energy conversion routes to be evaluated should include:
combustion, gasification, digestion and conversion to liquid fuels.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$30,656			$30,656

REPORTS

ABDALLAH B., AL-TAWEELS A.M., PROCOS D., Technical University of N.S., Assessment of Potential for a Sustained Energy Supply for the Agriculture and Food System for the Maritime Region. 1982

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 216

TITLE	Assessment of Lunaria as a Prospective Crop for Fuels and Industrial Oils	**PROGRAM IDENTIFICATION**	4.3.1.7 Biomass Resource Assessment/ Agriculture, Energy Crops
CONTRACT #	34SZ.1843-1-ER01 (0SZ81-58)	**DURATION**	October 1981 to October 30, 1983
CONTRACTOR	Enersearch c/o Federated Cooperative Limited 401 - 22nd Street Saskatoon, Saskatchewan S7K 3M9	**COST**	$10,000
		SPONSOR	Agriculture Canada
PRINCIPAL INVESTIGATOR	Brian Dykes Tele.: (306) 224-3300	**SCIENTIFIC AUTHORITY**	M. Stumborg Agriculture Canada Research Branch Research Station Swift Current, Saskatchewan S9H 3X2 Tele.: (306) 733-4621

OBJECTIVE

To assess Lunaria as a prospective crop for fuels and industrial oils.

DESCRIPTION

Phase 1

1. The contractor shall conduct a comprehensive literature search on Lunaria sp. related to its agronomic properties and potential uses as industrial chemicals and fuels.
2. The contractor shall obtain sufficient quantity of Lunaria annua and biennis to initiate laboratory analysis and plant field test plots.
3. The contractor shall perform laboratory analyses including extraction of the seed oil and the determination of % content and composition by GLC of its methyl esters, viscosities, density, and calorific value.
4. The contractor shall examine the residual meal to determine the nature and levels of the glucosinolates present, the protein, crude fibre and ash content, ADF/NDF analysis and amino acid composition of the meal.

Phase 2

1. The contractor will design a field trial test plan in collaboration with the scientific authority and other Agriculture Canada staff as required. The test plan will include details of the planting configuration and assessment of potential yield, agronomic properties such as maturity, height, lodging, or others as mutually agreed to by the scientific authority and the contractor. The field trials will be sufficiently large to provide a seed supply required for potential future large scale field trials.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 5,000			$ 5,000
1982-83	$ 5,000			$10,000

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 217

TITLE	Assessment of Milkweed as a Potential Renewable Fuel Crop	**PROGRAM IDENTIFICATION**	4.3.1.7 Biomass Resource Assessment/ Agriculture - Energy Crops
CONTRACT #	34SZ.1843-1-ER02 (0SZ81-69)	**DURATION**	October 1981 to November 30, 1983
CONTRACTOR	Enersearch c/o Federated Cooperative Ltd. 401 - 22nd Street Saskatoon, Saskatchewan S7K 3M9	**COST**	$76,835
		SPONSOR	Agriculture Canada
PRINCIPAL INVESTIGATOR	Brian Dykes Tele.: (306) 244-3300	**SCIENTIFIC AUTHORITY**	M. Stumborg Agriculture Canada, Research Branch, Research Station Swift Current, Saskatchewan S9H 3X2 Tele.: (306) 773-4621

OBJECTIVE

To assess the potential of milkweed as an energy crop.

DESCRIPTION

Phase 1 The contractor will design a field trial test plan in collaboration with the scientific authority and other Agriculture Canada staff as required. The test plan will be designed within the bounds of the milkweed seed plantings that were established by the contractor during the fall of 1980. The test plan will include details of agronomic practices (e.g. optimum levels of fertilizer, irrigation, weed control, etc. versus non-intensive levels of agronomic inputs, and multiple harvests versus single harvest), agronomic properties (e.g. maturity, yield, soil analysis, dry matter, etc.) and chemical properties (e.g. fiber, ash, in vitro digestibility, protein content of the residual biomass, extractable crude oil, C/H/N analysis, calorific content, and if possible chemical composition and molecular weight distribution).
Phase 2 The contractor will design an animal feeding trial test plan in collaboration with the scientific authority and other Agriculture Canada staff as required. The test plan will be designed to investigate the feed value of oil extracted milkweed residue in terms of palatability, toxicity, digestibility, or other parameters.
Phase 3 The contractor will: 1) carry out the field trial test plan as described in Phase 1; 2) carry out the animal feeding trial test plan as described in Phase 2; 3) carry out a detailed evaluation and analysis of the oil fraction at each of two separate laboratories (the oil will be assessed qualitatively and quantitatively as a refinery feedstock for liquid fuel or chemical production); 4) assess the residual plant material in terms of yield, availability, potential value, and byproduct utilization as protein, fibre or liquid fuels; 5) carry out an initial selection of plant breeding stock based on the morphology of the plan and wild colony of which it is a member; 6) collect seed from wild colonies to assist in further establishing replicated plots for possible future yield and agronomic studies and; 7) make preliminary suggestions on farm cultivation, harvesting and extraction, industrial extraction and refinery, end-uses, marketing and future R&D requirements.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$30,000			$30,000
1982-83	$46,835			$76,835

REPORTS

STATUS AND COMMENTS

The project is a continuation of a preliminary study on Showy Milkweed that was carried out in 1980 by the Sastakchewan Research Council. The preliminary study cost was $34,000 and was funded equally by Federated Co-operatives Ltd. and CSP Foods. M.S. 83/04/26

PROJECT DATA SHEET # 305

TITLE	Assessment of the Potential of Growing Unconventional "Energy Crops" or Multi-use Crops on Saline or Marginal Land	**PROGRAM IDENTIFICATION**	4.3.1.7 Biomass Resource Assessment/ Agriculture - Energy Crops
CONTRACT #	01843-1-ER05 (OSZ81-00121)	**DURATION**	April 1, 1981 to April 1, 1984
		COST	$538,273
CONTRACTOR	Saskatchewan Research Council 30 Campus Drive Saskatoon, Saskatchewan S7H 0X1	**SPONSOR**	Agriculture Canada
PRINCIPAL INVESTIGATOR	Wayne Craig Tel.: (306) 664-5415	**SCIENTIFIC AUTHORITY**	W.L. Crowle Research Station Agriculture Canada 107 Science Crescent Saskatoon, Saskatchewan S7N 0X2 Tel.: (306) 343-8214

OBJECTIVE

DESCRIPTION

Phase I The contractor will design a field trial test plan for the growing of potential agriculture liquid fuel crops or multi-use crops on saline or marginal lands. These crops will include kochia, Jerusalem artichoke, fodder beet, and the others which have been established as a current SRC in-house project. Possible criteria for evaluation will be stand establishment, salinity tolerance, yield, agronomic benefits, and projected usefulness of end products.
Phase II Those plants identified in the Phase I interim report will be planted on replicated field plots. Agronomic properties to be examined are to include planting densities, yields, levels of salinity tolerance, germination, and plant development. Six samples of material are to be made from the plots at different times to determine above-ground dry matter yield and composition.
Phase III Using feedstocks from plant species grown during Phase II, the contractor will perform the following investigations:
1) Production and isolation of sources of cellulolytic enzymes.
2) Design fermentation systems to digest cellulose and hemicellulose.
3) Examine pretreatment methods both chemical and physical.
4) Analyse the hydrolysate and determine rates.
Phase IV The contractor will perform studies of cell wall chemistry, structure and biology, microbiology of enzyme transformation and physico-chemical transformation of forages, crop residues and other energy crops identified in Phase I to determine why one material is more digestible than another and what are the specific effects of chemical or biological agents in improving digestibility.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$100,000	$ 48,002		$148,002
1982-83	$125,000	$ 61,250		$334,252
1983-84	$134,022	$ 70,000		$538,273

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 311

TITLE	Rye-Corn Sequences for Biomass Production	**PROGRAM IDENTIFICATION**	4.3.1.7 Biomass Resource Assessment/ Agriculture - Energy Crops
CONTRACT #	01916-2-ER23 (OSU82-00089)	**DURATION**	June 2, 1982 to March 31, 1985
CONTRACTOR	University of Guelph Dept. Crop Science Guelph, Ontario N1G 2W1	**COST**	$198,534
		SPONSOR	Agriculture Canada
PRINCIPAL INVESTIGATOR	T.B. Daynard	**SCIENTIFIC AUTHORITY**	J.M. Elliot Agriculture Canada Research Branch Research Station Delhi, Ontario N4B 2W9 Tel.: (519) 582-1950

OBJECTIVE

DESCRIPTION

1. To obtain biomass yields from a two-crop sequence of winter-rye & corn & evaluate cultural alternatives and requirements for maximizing and/or optimizing the total dry matter yield.
2. To measure effects of the cropping sequence on the physical quality of the soil and determine the effects of the soil structure created by rye on photosynthesis and biomass yield of corn.
3. To evaluate the utility of sorghum for inclusion in a double-crop sequence with winter rye for biomass production.
4. To determine the liquefaction pyrolysis product yield of low-lignin biomass from rye and corn.
5. To provide an estimate of the agronomic costs of production for the projection of feedstock costs.
6. To provide proximate chemical analyses and calculate potential yields of ethanol, methanol, pyrolytic oils and oven-dry biomass on a hectare basis.
7. To provide a complete economic and energy input-output evaluation of rye-corn for biomass productivity and the potential liquid-fuel yields.
8. To evaluate the utility of sunflower for inclusion in a double-crop sequence with Winter rye for biomass production.
9. To provide an estimate of economics and energy input-outputs of rye-sorghum and rye-sunflower sequences for biomass productivity and the potential liquid fuel yields.
10. To provide information on procedures for storing wet biomass from rye-corn, rye-sorghum & rye/sunflower as silage in horizontal silos, for the preservation during time intervals between harvesting and utilization.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$59,627			$ 59,627
1983-84	$64,225			$123,852
1984-85	$74,682			$198,534

REPORTS

Five progress reports received on Rye-Corn Sequence for biomass production.

STATUS AND COMMENTS

Progress is quite satisfactory. T.B.D.

83/04/12

PROJECT DATA SHEET # 315

TITLE Assessment of the Agronomic, Technical & Economic Feasibility of Producing Jerusalem Artichokes for Energy Crop

CONTRACT # 01843-1-ER20 (0SZ82-00022)

CONTRACTOR SunRoot Energy Limited
Suite 3400
The Exchange Tower
2 First Canadian Place
Toronto, Ontario
M5X 1J3

PRINCIPAL INVESTIGATOR P.W. Billingsley

PROGRAM IDENTIFICATION 4.3.1.7
Biomass Resource Assessment/ Agriculture - Energy Crops

DURATION April 28, 1982
to April 28, 1984

COST $261,912

SPONSOR Agriculture Canada

SCIENTIFIC AUTHORITY Gary Hergert
Engineering & Statistical Research Institute
Research Branch
Agriculture Canada
Building 94
Ottawa, Ontario
K1A 0C6
Tel.: 995-3151

OBJECTIVE

DESCRIPTION

1. Investigate, implement and develop the agronomic aspects of the crop including: (a) variety evaluations, (b) site evaluations, (c) yield evaluation of foliage and tubers, (d) assessment of the effect of fertilizer and pH levels on the yield of the Jerusalem Artichoke.
2. Measure the energy inputs of producing the crop and report on the economic feasibility of producing the crop by: (a) recording the fuel usage during operations, (b) recording fertilizer usage, (c) measuring yields, (d) recording records of manpower inputs.
3. Investigate, evaluate and develop the equipment needs for the crop by: (a) testing existing equiment, (b) developing or modifying equipment, in cooperation with Canadian manufacturers where possible, to suit the special needs of the crop, (c) evaluating and reporting on the capacity and the efficiency of the equipment.
4. Demonstrate the production system on at least 12 ha the first year and 40 ha the second year with auxiliary plantings of at least 1 ha in Eastern Ontario and 1 ha in Northern Ontario.
5. Evaluate the feasibility of feeding the by-product of fermentation to cattle and to pigs.
6. Assess the sugar and feed composition values at different stages of growth for the tops and tubers, and of the fermentation mash.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$159,177			$159,177
1983-84	$102,735			$261,912

REPORTS

STATUS AND COMMENTS

Twelve ha of Jerusalem Artichoke was planted in 1982. A planter, seed slicer and harvester was purchased and modified. Yield determinations will be made in early spring harvest. P.W.B.

83/04/29

ENVIRONMENTAL EFFECTS

Forestry - Silvicultural and Harvest Impacts

Forestry - Conversion Technology Impacts

Agricultural - Agricultural and Harvesting Impacts

Agricultural - Conversion Technology Impacts

Peat - Harvesting

Peat - Conversion Technology

PROJECT DATA SHEET # 82

TITLE	Nature and Extent of the Impact of Forest Biomass Harvesting on the Forest Environment.	**PROGRAM IDENTIFICATION**	4.3.2.1 Biomass Environmental Effects/Forestry-Silvicultural and Harvesting Impacts.
CONTRACT #	KL004-9-0012 (OSD79-000014) P-95, P-155	**DURATION**	June 1979 - March 1984
CONTRACTOR	Le Groupe Dryade Ltée. 642, boul. St. Cyrille O. Québec, Québec. G1S 1S8	**COST**	$347,979
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	Jean-Louis Blouin Tél.: (418) 681-0687	**SCIENTIFIC AUTHORITY**	Gilles Frisque Laurentian Forest Research Centre Canadian Forestry Service 1080 route du Vallon Ste-Foy, Québec G1V 4C7 Tél.: (418) 653-2143

OBJECTIVE

To identify and assess the relative importance of forest environmental potential changes brought about by forest biomass harvest. To estimate the time required for normal ecosystem recovery. To prepare preliminary guidelines for environmental monitoring and protection.

DESCRIPTION

The principal objective of the study entails the identification (based on the literature concerning potential impacts resulting from forest biomass harvesting) of the variables pertaining to the forest environment that are most susceptible to being influenced by such a harvesting. It also entails the quantification, if possible, of the intensity of the modifications these variables undergo. The former task has permitted the identification of those elements within a monitoring program that are feasible for use as indicators of the impacts on the forest environment resulting from biomass harvesting. The study outline adopted consists of six phases shown.

- Selective bibliographical review
- Information treatment
- Matrix of simple (natural) correlations
- CNYR Matrix of impacts (1972)[2]
- Flow-diagram of interrelationships
- Simplified or thematic flow-diagrams
- Strategy, application procedures and monitoring. Pre- and postcut inventory of environmental variables.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1979-80	$ 40,000			$ 40,000
1980-81	$120,000			$160,000
1981-82	$ 46,000			$206,000
1982-83	$ 59,979		$ 2,000	$267,979
1983-84	$ 80,000			$347,979

REPORTS

Evaluation of Potential Impacts of Forest Biomass Harvesting, by Le Groupe Dryade, August 1980. ENFOR Project P-95, LAU-X-45E (Available from ENFOR Secretariat and the Energy Library, CISTI).

Évaluation des impacts potentiels de la récolte de la biomasse forestière, par Le Groupe Dryade, août 1980. Projet ENFOR P-95, LAU-X-45 (Disponible au Secrétariat ENFOR et à ICIST - Section d'Énergie).

STATUS AND COMMENTS

83/04/25

PROJECT DATA SHEET # 95

TITLE	Modelling of the Long-term Consequences of Intensive Biomass Harvesting on Soil Fertility and Biomass Production.	**PROGRAM IDENTIFICATION**	4.3.2.1 Biomass Environmental Effects/Forestry-Silvicultural & Harvest Impacts
CONTRACT #	05SS.KL011-9-0006 (0SS79-00060) P71	**DURATION**	April 1979 - March 1983
		COST	$454,908
		SPONSOR	Environment Canada
CONTRACTOR	Faculty of Forestry University of British Columbia Vancouver, B.C. V6T 1W5	**SCIENTIFIC AUTHORITY**	L. Chatarpaul Canadian Forestry Service Petawawa National Forest Institute Chalk River, Ont. K0J 1J0 (613) 589-2880
PRINCIPAL INVESTIGATOR	J.P. Kimmins Tel.: (604) 228-4701		

OBJECTIVE

To refine existing computer model to render it a useful practical tool for forest management planning.

To obtain data from three types of forest environment to calibrate, validate and refine the model.

DESCRIPTION

Forest biomass in a sequence of stands varying over the age range expected in a managed forest will be estimated using existing allometric regressions (these will be tested before acceptance). Minor vegetation biomass will be measured by clipping-plots. Nutrient content of all biomass components, and nutrient cycling by litter-fall, leaching, internal cycling and decomposition will be investigated by standard techniques. Estimates of soil fertility and rooting depth will be obtained. Additional parameters will be investigated as demanded by the refined computer model. This work will be conducted at coastal low elevation, coastal high elevation and interior sub-boreal forest locations. Data from other Canadian forest environments will be used where possible.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1979-80	$ 50,803			$ 50,803
1980-81	$ 68,808			$119,611
1981-82	$168,200			$287,811
1982-83	$162,097		$ 5,000	$454,908

REPORTS

Interim reports held by scientific authority.

STATUS AND COMMENTS

Phase three of this project is referenced as ENFOR - P-197.

83/04/25

PROJECT DATA SHEET # 105

TITLE	Effects of harvesting biomass for energy on the nutrient status and long term productivity of selected forest sites in the Maritimes	**PROGRAM IDENTIFICATION**	4.3.2.1 Environmental Effects/ Forestry - Silvicultural and Harvest Impacts
CONTRACT #	07SC.KL003-9-0020 (0SC79-00086) P40	**DURATION**	May 1979-March 1983
		COST	$170,588
		SPONSOR	Environment Canada
CONTRACTOR	Institute for Resources & Environmental Studies Dalhousie University Halifax, N.S.	**SCIENTIFIC AUTHORITY**	Mr. G.D. van Raalte Maritimes Forest Research Centre, C.F.S. Box 4000 Fredericton, N.B. E3B 5P7 (506) 452-3549
PRINCIPAL INVESTIGATOR	Dr. A. Hanson		

OBJECTIVE

To determine the contents of major nutrient elements in the tree layer (by tree components), shrub layer, surface organic layer, and upper mineral soil on a series of sites of different inherent fertility levels, occupied by stands of different species composition and stages of development. To determine the quantities of nutrients which are being added to, circulated within, and removed in the form of biomass from the ecosystem at each selected site. To evaluate the effects on the nutrient cycle and long-term maintenance of productivity of biomass removal for energy purposes.

DESCRIPTION

The study will take four years to complete and should provide essential, quantitative information on the nutrient effects of biomass removal. It will also permit the identification of those sites incapable of supporting biomass removal without significant loss of fertility and productivity. The work will be carried out in Nova Scotia because a large proportion of the forest sites in that Province are of low fertility.

Two areas, each having relatively uniform geology and well-drained soils but of different levels of inherent fertility (one markedly nutrient deficient, corresponding to C.L.I. class 6; the other of average or slightly above average fertility, corresponding to C.L.I. class 4/5) will be selected in western or central Nova Scotia, probably in the Anna-King Crown Land Block. In each area twenty-five .04 ha plots will be laid out - five under each of the following cover types: mature softwoods, young (pole stage) softwoods, mature hardwoods, young hardwoods, recent (1978 and/or 1979) whole-tree harvested cutovers.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1979-80	$34,435			$ 34,435
1980-81	$49,990			$ 84,425
1981-82	$49,990			$134,415
1982-83	$34,173		$ 2,000	$170,588

REPORTS

"Effects of Harvesting Biomass for Energy on the Nutrient Status and Long-term Productivity of Selected Forest Sites in the Maritimes - Annual Report", 1979-80, M.K. Mahendrappa, Dalhousie University. (Available from ENFOR Secretariat)

STATUS AND COMMENTS

Various sites as outlined above were selected and characterized in terms of tree heights and dbh, and by describing soil profiles. Bulk rain samplers were set up in recently clearcut open areas. Ground vegetation and soil were sampled from these open areas. Two 0.5 ha blocks in a mature softwood stand were harvested to estimate (one under the conventional and the other under whole tree harvesting conditions), the biomass and nutrients removed from the sites under different harvesting methods. In all these sites, five 0.04 ha plots were laid out for further study.

83/04/26

PROJECT DATA SHEET # 170

TITLE	Impact of Biomass Production on Wildlife	**PROGRAM IDENTIFICATION**	4.3.2.1 Environmental Effects/ Forestry - Silvicultural and Harvest Impacts
CONTRACT #	KL229-0-4224 (OSS80-106) P170	**DURATION**	April 1980-March 1983
CONTRACTOR	Le Groupe Dryade Ltée 2090 chemin Ste-Foy Québec, Qué. G1V 1R6	**COST**	$80,335
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	R. Coulombe	**SCIENTIFIC AUTHORITY**	E.S. Telfer Canadian Wildlife Service Western and Northern Region Environment Canada 1000-9942, 108th Street Edmonton, Alberta T5K 2J5

OBJECTIVE

Through discussions with foresters involved in ENFOR projects as well as other federal, provincial, university and private industry foresters, to assemble information on the form that forest management might take to produce maximum biomass.

DESCRIPTION

1. The assembled information would serve as the basis for conceptual models of the type of forest landscape that would result in the various forest regions and sections of Canada if management for energy production becomes common. This would include species composition, stand regeneration and tending techniques, stand areas and interspersions, road networks and harvesting techniques.
2. Impacts on wildlife and wildlife damage to forests would be predicted based on probable landscapes and management practices and on knowledge of habitat requirements of various wildlife species.
3. Special attempts will be made to identify and assemble information on rare or vulnerable forest wildlife and plants.
4. A search will be conducted for written material relating to the above problems that are relevant to Canada.
5. Make recommendations on the measures or constraints required in biomass production forestry to conserve wildlife, particularly rare and vulnerable species, and to hold costs of wildlife damage to forests at an acceptable level.
6. Make recommendations to guide the ENFOR program regarding funding of studies of wildlife problems relating to biomass forestry that appear in urgent need of study.
7. Make further recommendations on research needed to evaluate potential impact and damage problems in various forest regions and provinces, by order of priority.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$57,500			$57,500
1981-82	$ 1,000			$58,500
1982-83	$21,835			$80,335

REPORTS

STATUS AND COMMENTS

84/04/26

PROJECT DATA SHEET # 224

TITLE	Impact of Forest Biomass Production on Reptiles and Amphibians in the Great Lakes - St. Lawrence Forest Region	**PROGRAM IDENTIFICATION**	4.3.2.1 Environmental Effects/ Forestry - Silvicultural and Harvest Impacts
CONTRACT #	KN107-1-4316 (OSG81-00002) P-226	**DURATION**	October 1981 - March 1983
		COST	$47,330
CONTRACTOR	The Environmental Applications Group Limited 114 Avenue Road Tororto, Ontario M5R 2H4	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	E.S. Telfer Canadian Wildlife Service Western and Northern Region Environment Canada 1000-9942 168th Street Edmonton, Alberta T5K 2J5
PRINCIPAL INVESTIGATOR	D.A. Simms		

OBJECTIVE

The project is designed to evaluate the impact on reptiles and amphibians of management of forest lands for maximum production of biomass in the Great Lakes - St. Lawrence Forest Region in Central and Eastern Ontario and Southern Québec.

DESCRIPTION

The project studies will involve:

1. Preparation of an annotated bibliography of the world literature relating to the impact of forest management practices on reptiles and amphibians.
2. Prediction of management practices likely to be employed in biomass production in the area of the study with potential proportions of the area suitable for such paractices.
3. Field study to establish preferred habitat conditions for reptile and amphibian species in the area with special attention to rare or vulnerable forms.
4. Field measurement to provide quantitative data on habitat parameters.
5. Analyses of quantitative habitat descriptions to estimate gains or losses in habitat for various species likely to result from biomass production.
6. Recommendations regarding suitable mitigation procedures where advisable to safeguard forms rare in Ontario or Québec.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$20,000			$20,000
1982-83	$24,030		$ 3,300	$47,330

REPORTS

STATUS AND COMMENTS

83/03/26

PROJECT DATA SHEET # 276

TITLE	Impact of Harvesting Mature Trees by Whole-Tree Method on the Microbiology, Organic Matter & Nitrogen Transformations of a Forest Soil	**PROGRAM IDENTIFICATION**	4.3.2.1 Environmental Effects/ Forestry - Silvicultural & Harvest Impacts
CONTRACT #	KL011-1-0010 (05581-00040) P-199	**DURATION**	May 12, 1981 to March 31, 1984
		COST	$143,093
CONTRACTOR	University of Guelph Guelph, Ontario N1G 2W1	**SPONSOR**	Environment Canada
PRINCIPAL INVESTIGATOR	J.B. Robinson Dept. of Environmental Biology	**SCIENTIFIC AUTHORITY**	L. Chatarpaul Canadian Forestry Service Environment Canada Petawawa National Forestry Institute CHALK RIVER, Ontario K0J 1J0 Tele.: (613) 589-2880

OBJECTIVE

To understand the effects of whole-tree harvesting on the soil microorganisms and processes expecially those concerned with nitrogen transformations to provide a sound basis for designing forest soil management techniques aimed at the maintenance of site productivity.

DESCRIPTION

1. Review and report on the existing information about the impact of intensive forest managment practices on soil microbiology and processes especially those concerned with organic matter and nitrogen transformation.
2. Selection of a suitable forest site and the establishment of experimental plots.
3. Determine relative numbers of various groups of bacteria important in the N cycle as affected by harvest treatment including amonifiers, nitrifiers and denitrifiers. Their distribution down the soil profile will also be determined.
4. Characterize soils as to changes in organic matter content and changes in the rate of decomposition and mineral composition as determined by burying litter in bags and also by measuring gross soil respiration and analysing decomposed material.
5. Determine process rates of nitrification(by soil perfusion or a suitable method) and amonification (by incubation) for soils at least 3 times per year.
6. As required, obtain soil samples for chemical analysis (N, P, K, Ca, Mg, Mn, B, Cu, An, Fe) and record temperature, moisture, pH and CEC.
7. Conduct laboratory experiments on the effects of such factors as pH, temperature, moisture organic matter on the microbiology and related processes in the affected soils.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$38,410			$ 38,410
1982-83	$42,903		$18,600	$ 99,913
1983-84	$43,180			$143,093

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 291

TITLE	Impact on Wildlife of Short-Rotation Management in Boreal/ Aspen Stands	**PROGRAM IDENTIFICATION**	4.3.2.1 Environmental Effects/ Forestry - Silvicultural & Harvest Impacts
CONTRACT #	KL229-1-4109 (OSS81-00018) P-203	**DURATION**	April 21, 1981 to March 31, 1983
CONTRACTOR	Westworth, D.A. & Assoc. Ltd. 6805 - 104 Street Edmonton, Alberta T6H 2L5	**COST**	$56,237
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	E.S. Telfer Western & Northern Region Canadian Wildlife Service Environment Canada 1000, 9942 - 108 Street Edmonton, Alberta T5K 2J5 Tele.: (403) 435-7341

OBJECTIVES

1. Complete an inventory of habitat composition and forage production in each type of forest stand
2. Determine use of sample stands by birds and large mammals.

DESCRIPTION

The work program will include:

1. An inventory of forest stand composition, including the species composition and density of herbaceous vegetation.
2. An inventory of snags and downed woody material and a description of the use of snags for feeding or nesting by birds and mammals.
3. An inventory of mass per ha of forage production in representative sample stands.
4. A comparative study of use of sample stands by breeding bird populations.
5. Pellet group counts to determine use of sample stands by ungulates.
6. Winter track counts to determine the use of sample stands by ungulates and fur-bearing mammals.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$32,931			$32,931
1982-83	$22,306		$ 1,000	$56,237

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 295

TITLE	Nutrient Content of Various Types & Parts of Plant Samples from the Forest at Petawawa National Forestry Institute	**PROGRAM IDENTIFICATION**	4.3.2.1 Environmental Effects/ Forestry - Silvicultural and Harvest Impacts
CONTRACT #	KH415-2-0647 (OSU82-00239) P-233	**DURATION**	Sept. 10, 1982 to March 31, 1983
		COST	$13,868
CONTRACTOR	University of Guelph Soil Testing Lab. Dept. of Land Resource Science Guelph, Ontario N1C 2W1	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	D.M. Burgess Environment Canada Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario K0J 1J0 Tele.: (613) 589-2880
PRINCIPAL INVESTIGATOR	E.G. Beauchamp		

OBJECTIVE

The analysis of the nutrient (N, P, K, Ca, Mg, B, Cu, Mn, Zn, and Fe) content of various types and parts of plant samples growing in the forest at the Petawawa National Forestry Institute, and also the nutrient (P, K, Ca, Mg, Al, Cu, Mn, Zn and Fe) content of soil samples.

DESCRIPTION

1. To analyze 232 samples plus 8 controls of stemwood, branch wood foliage and bark for the nutrients (N, P, K, Ca, Mg, B, Cu, Mn, Zn, and Fe. The results will be expressed in per cent concentration on an oven dry weight basis (80°c). Concentration below 0.2% should be expressed as parts per million. Nitrogen analyses should be done by the Microkjeldahl method.

2. To analyze 95 soil samples plus 5 controls, air-dried and numbered for the nutrients P, K, Ca, Mg, Al, Cu, Mn, Zn, and Fe.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$11,368		$ 2,500	$13,868

REPORTS

STATUS AND COMMENTS

83/04/27

SILVICULTURE

PROJECT DATA SHEET # 107

TITLE	Nitrogen-fixing & Mycorrhizal Symbioses in Forests to Increase Biomass Production & Maintain Soil Fertility	**PROGRAM IDENTIFICATION**	4.3.4 Silviculture
CONTRACT #	KL011-9-0007 (OS079-47) P78, P198	**DURATION**	April 1979-March 1983
		COST	$348,970
		SPONSOR	Environment Canada
CONTRACTOR	Faculté Forestière Université de Laval Ste-Foy, Qué. G1K 7P4	**SCIENTIFIC AUTHORITY**	L. Chaterpaul Canadian Forestry Service Petawawa National Forestry Institute Environment Canada Chalk River, Ont. K0J 1J0
PRINCIPAL INVESTIGATOR	André Fortin (418) 656-2384		

OBJECTIVE

To find ways of increasing productivity and maintaining soil fertility of intensive forestry systems grown to produce biomass using nitrogen-fixing species to reduce dependence on fertilizers that are costly in terms of dollars and energy.

DESCRIPTION

1. Prepare a report summarizing available information of N-fixation in forests, its potential as a management tool to increase yield of biomass and maintain soil fertility and need for further research.

2. Establish experiments to examine effects of N-fixing symbioses on yield and soil fertility and, to study the mechanisms involved.

3. Select superior N-fixing genotypes.

4. Examine nitrogen pathway.

5. Attempt to control and produce the Alder endophyte (Frankia).

6. Search for mycorrhizae common to Alder and other tree species to facilitate nitrogen transfer from one species to another.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1979-80	$ 39,814			$ 39,814
1980-81	$ 54,486			$ 94,300
1981-82	$116,840		$ 1,500	$212,640
1982-83	$133,330		$ 3,000	$348,970

REPORTS

FORTIN J. André, Université Laval, Uses of Nitrogen Fixation and Other Root Symbioses for Biomass Production. Ste. Foy, Québec. (Interim Report, May 1981.) ENFOR Project P-78. (Available from ENFOR Secretariat and Energy Library)

FORTIN J. André, Université Laval, Uses of Nitrogen Fixation and Other Root Symbioses for Biomass Production. Ste. Foy, Québec. (Interim Report, March 1982.) ENFOR Project P-198 (P-78).

STATUS AND COMMENTS

Sites selected, plants raised for planting in 1980. Nitrogen pathway and screening experiment in progress. Common mycorrhizae (Alnus and Picea) located (Paxillus). Frankia production under control.

Interim report dated May 1981 covers work performed to July 1980 but does not attempt to synthesize the research results. Such will be the content of subsequent reports.

Interim report dated March 1982 also available. 83/04/26

PROJECT DATA SHEET # 275

TITLE	Experimental Plantations of *Alnus* sp. for Energy	**PROGRAM IDENTIFICATION**	4.3.4 Silviculture
CONTRACT #	KL004-1-C001 (QUE80-7432/1) P-194	**DURATION**	1980-1983
CONTRACTOR	Pampev Inc. Rang St-Lazare St-Apolinaire, Québec G0S 2E0	**COST**	$49,489
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	Françoise Labine Tel.: (418) 767-3114	**SCIENTIFIC AUTHORITY**	Gilles Frisque Laurentian Forest Research Centre Canadian Forestry Service 1080 route du Vallon STE-FOY, Québec G1V 4C7 Tele.: (418) 653-2143

OBJECTIVE

1. To field-check the potential of *Alnus* species for biomass production on short rotations.

2. To field-check the efficiency of the association of nitrogen-fixing microorganisms and alders.

DESCRIPTION

Alnus seedlings have been grown in greenhouses to a height of 15 cm when they are planted in the field. All seedlings were inoculated with nitrogen-fixing microorganisms, thus avoiding expensive N-fertilization.

Field planting was done in early June, at densities between 2500/ha & 15,000/ha.

Survival, growth, biomass production (ODt/ha) and nitrogen-fixation efficiency will be assessed for 2 years after planting.

The plantation will be harvested after 5 years using available machinery. The results obtained will complete trials carried out with other species in Québec in an "energy plantation" context.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1980-81	$ 5,470			$ 5,470
1981-82	$30,519			$35,989
1982-83	$12,000		$ 1,500	$49,489

REPORTS

STATUS AND COMMENTS

The contract was amended to include the planting of 5,000 poplar cuttings at the Alder plantation site. This project includes a number of contracts for plantation land clearing and drainage:
FY 1980-81 - Total $ 5,470
FY 1981-82 - Total $15,519

83/04/27

PROJECT DATA SHEET # 290

TITLE	Salix for Biomass Fuel and Energy Conservation	**PROGRAM IDENTIFICATION**	4.3.4 Silviculture
CONTRACT #	KH205-1-125 (OSC 82-15) P-172	**DURATION**	1981-1983
CONTRACTORS	1. W.C. Wilton St. John's, Nfld. 2. A. Dyer St. John's, Nfld.	**COST** TOTAL	$ 38,810
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	R.S. van Nostrand Nfld. Forest Research Center Canadian Forestry Service Box 6028 St. John's, Nfld. A1C 5X8

OBJECTIVE

To acquire and test propagative material of fast growing species and hybrids of Salix for use as a fuel in Newfoundland.

DESCRIPTION

Fast-growing Salix clones were acquired from British Isles, Ireland, and Scandinavia.

Additional clones were also obtained from local collections and other North American sources. The propagative material is being screened and cultivated in clone banks. As material becomes available, trial plantations will be established using agro-forestry techniques.

A pilot study of potential land use for energy plantations on the Avalon Peninsula was carried out.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
81-82			$11,700	$11,700
82-83	1. $11,969 2. $13,641		$ 1,500	$38,810
82-83				

REPORTS

DYER A., A Pilot Study on the Feasibility of Establishing Willow Energy Plantations in Nfld.. Contractor's Report, 34 p. & maps., 1983

WILTON W.C., Salix for Biomass Fuel and Energy Conservation. Contractor's Report (In Press). 1983.

STATUS AND COMMENTS

Project completed.

83/04/27

PROJECT DATA SHEET # 294

TITLE	Transfer of Nitrogen Fixing Capability from Alder (Alnus) to birch (Betula)	**PROGRAM IDENTIFICATION**	4.3.4 Silviculture
CONTRACT #	KH415-1-1252 (OSS81-00210) P-232	**DURATION**	February 19, 1982 to March 31, 1984
CONTRACTOR	University of Laval Sainte-Foy, Québec G1K 7P4	**COST**	$53,095
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	M. Lalonde	**SCIENTIFIC AUTHORITY**	L. Chatarpaul Environment Canada Canadian Forestry Service Chalk River, Ontario K0J 1J0 Tele.: (613) 589-2880

OBJECTIVE

To provide a basis for development of a nitrogen-fixing Betula/Frankia symbiosis to increase fibre yield and maintain nitrogen levels of forest soils by selecting, culturing, and fusing Betula and Alnus protoplasts as a precursor to overcoming the infectivity barrier between Betula and Frankia.

DESCRIPTION

1. Select and grow in the greenhouse germ plasm of different Alnus species, e.g. Alnus crispa, A. rugosa, A. glutinosa, A. rubra and A. cordata.
2. Select and grow in the greenhouse germ plasm of Betula papyrifera.
3. Isolate the protoplasts from Alnus and Betula types.
4. Cultivate in vitro the isolated protoplasts of Alnus and Betula.
5. Select different protoplast marker mutants, chlorophyll deficient mutants, antibiotic resistant mutants, metabolic mutants, infectivity mutants of Frankia.
6. Attempt to produce hybrids by the polyethylene glycol-induced fusion of Alnus protoplasts with Betula protoplasts.
7. Screen and recover fused protoplasts.
8. Cultivate in vitro selected somatic hybrids of Alnus and Betula.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$25,845		$ 4,000	$29,845
1983-84	$23,250			$53,095

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 304

TITLE	Land Application of an Industrial Sludge to Hybrid Poplar Plantations - A Lysimeter Study	**PROGRAM IDENTIFICATION**	4.3.4 Silviculture
CONTRACT #	KN107-2-4425 (OSS82-00108) P-248	**DURATION**	October 12, 1982 to March 15, 1983
		COST	$5,000
CONTRACTOR	Du Pont Canada Inc. Maitland Works P.O. Box 611 Maitland, Ontario K0E 1P0	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	Mel Webber Residue Management Section Environmental Protection Service 867 Lakeshore Road Burlington, Ontario L7R 4A6
PRINCIPAL INVESTIGATOR			

OBJECTIVE

1. Determining the nitrogen uptake capacity of hybrid poplars grown on soil taken from the site and amended with sludge.
2. Determining the growth response and nutrient and heavy metal uptake by poplars grown on the sludge treated soils.
3. Determing the nutrient and heavy metal concentrations in leachates collected from the sludge amended soils.
4. Determining the effect on soil structure and permeability of high sodium concentrations in the sludge.

DESCRIPTION

Experimental Design No. of lysimeters - 44, No. of replicates - 4, No. of treatments - 11
Treatments: - Nitrogen fertilizer applied at 125, 250, 500 kg N/ha.yr
- Sludge; surface applied at 125, 250, 500, 1000 kg N/ha.yr
- Sludge; incorporated in 0-15 cm soil at 125, 250, 500, 1000 kg N/ha.yr

Phosphorus and potassium fertilization - 100 kg P/ha.yr and 250 kg K/ha.yr supplied to all treatments.
Soil - one type: Sludge - one type; dewatered to 10% solids: Hybrid Poplar - one species; four cuttings per lysimeter, supplied by the Ministry of Natural Resources

Plant Response and Analysis Several measurements of plant response are possible including; total plant height, girth at a given height, leaf size, leaf dry weight and total plant weight. It is also suggested that two plants from each lysimeter be harvested in early August of each year. Leaf and stem weight will be measured prior to preparation for analysis. Leaves and stem weight will be measured prior to preparation for analysis. Leaves and stems will be analyzed for N, P, K, Ca, Mg, Na, Cd, Zn, Cu, Ni, Pb, Cr and Mo and analyzed for total NO_2-N, NO_3-N, P, K, Na, Zn, Cu and Mo.
Soil Sampling and Analysis samples of 0-15 cm soil will be taken from each lysimeter prior to initiating the experiment and during September of years 1 and 2 and be analyzed for total N, Cd, Zn, Cu, Ni, Cr, Mo, cation exchange capacity, exchangeable Ca, Mg, K and Na.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 5,000			$ 5,000

REPORTS

Reports for the periods June to December 1982 and January to March 1983 will be completed prior to March 31, 1983.

STATUS AND COMMENTS

The study is on-going with a planned completion date of November 1984. Additional Environment Canada funding has been rquested but there is no commitment to date. M.W. 83/04/27

BIOMASS PLANTING, HARVESTING AND COLLECTION TECHNOLOGIES

PR

TI

CO

CO

P

JECT DATA SHEET # 78

LE	Field Treatment System for Logging Residues to Facilitate Transportation and Subsequent Conversion to Energy	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
TRACT #	KL017-9-1430 (OSB79-04) P-36 KL017-0-1037 (OSB80-400) P-183	**DURATION**	April 1979 - March 1983
		COST	$390,900
		SPONSOR	Environment Canada
ITRACTOR	Forestal International Ltd. 1550 Alberni Street Vancouver, B.C. V6G 1A5	**SCIENTIFIC AUTHORITY**	Dr. G.H. Manning Pacific Forest Research Centre Canadian Forestry Service 506 West Burnside Road Victoria, B.C. V8Z 1M5 (604) 388-3811
INCIPAL INVESTIGATOR	K.J. Blakeney (604) 683-6994		

JECTIVE

To develop a system for collecting and processing logging residues into a concentrated form prior to transportation to an energy conversion plant;
To determine, through field testing, the technical and economic feasibility of implementing the methods derived.

ESCRIPTION

. Test sites will be selected so that they contain a variety of material representing the species mix, the range of size and concentration of residues commonly found on coastal logging areas.

. A series of sample plots will be established to carry out inventory of residual forest biomass using available appropriate land clearing equipment. Loose biomass will be assembled and transported to the roadside. Land-firm biomass such as stumps and roots will be extracted using a stump splitter or explosives. Only a portion of the total test site will be cleared of stumps. By clearing to two different standards it will be possible to assess the effects of volume of the material recovered, collection costs, and quality of processed material. Mobile equipment will be used at the roadside, to convert biomass into an easily handled form for transport and energy conversion. Test equipment used will be other than that whose limitations and performance are already documented.

3. The maintenance of machine and labour time records for each distinguishable work phase will facilitate the production of unit cost for each phase or function performed and equipment modifications will be made to improve the limitation or to eliminate inadequacies.

4. Biomass will be sampled to determine volume and weight or material removed from the test site. The analysis will determine; 1) average density and range of particle size of material from a variety of source types; 2) average percentage composition by organic and inorganic components from different source types; 3) average green moisture content; and 4) calorific value of green, air dry, and oven dry material.

5. Processed biomass will be marketed as hog fuel or ground mulch where practical.

6. Contact will be maintained with Forest Engineering Research Inst. who is also undertaking studies on the harvesting of forest residue and its transportation to useable energy.

7. A report of the project will include a description of the equipment & procedures used and conclusions and recommendations.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1979-80	$144,900			$144,900
1981-82	$114,000		$ 1,000	$259,900
1982-83	$130,000		$ 1,000	$390,900

REPORTS

BLAKENEY K.J., Development and Testing of a Field Treatment System for Logging Residues to Facilitate Transportation and Subsequent Conversion to Energy. In proceedings of the Second Bioenergy R&D Seminar, Ottawa, Ontario, March 1980. pp 29-33. NRCC 18273 $15.00
(Available from NRC Publications)

STATUS AND COMMENTS

83/04/25

PROJECT DATA SHEET # 185

TITLE	Fabrication & Testing of a Front-End Piler	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	01SX.3115-2-2810	**DURATION**	April 1982 to March 31, 1983
CONTRACTOR	Do-Tan Manufacturing Limited 15 Hatt Street Dundas, Ontario. L9H 2G1	**COST**	$21,744
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	R.G. Doel Tel.: (416) 628-2241	**SCIENTIFIC AUTHORITY**	T.B. Golob National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tel.: (613) 993-1342

OBJECTIVE

To fabricate and test a front-end piler attachment for the Holder A60 tractor. This is a follow-on from 01SX-3115-2-2641.

DESCRIPTION

The front-end piler attachment for the Holder A60 test tractor was designed by Do-Tan Manufacturing Limited during the late summer 1982. The attachment was built during the fall and early winter 1982/83, and the laboratory and field testing is planned to take place during the month of March 1983. The attachment will be tested on the Holder A60 by collecting and carrying bunches of up to 15 trees to the roadside and loading them onto a stake type paltform trailer.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$21,744			$21,744

REPORTS

STATUS AND COMMENTS

The attachment has been built and it is scheduled for initial field testing in March 1983. T.B.G. 83/04/26

PROJECT DATA SHEET # 195

TITLE	Development of the RECUFOR & application of the RECUFOR rotor to comminution of residues at landings.	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies.
CONTRACT #	KL229-1-4203(0SS81-00095) P-210/P-215	**DURATION**	July 1981 - March 1983
		COST	$719,031
CONTRACTOR	Forest Engineering Research Institute of Canada 143 Place Frontenac Pointe Claire, P.Q. H9R 4Z7	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	B.J. Sutherland Great Lakes Forest Research Centre 1189 Queen Street Sault-Ste-Marie, Ontario
PRINCIPAL INVESTIGATOR	Denis Brière		

OBJECTIVE

1. The development of the RECUFOR.
2. Applications of the RECUFOR rotor to the comminution of residues at landings. The RECUFOR concept consists essentially of a powered, 3-foot diameter, cylinder equipped with 3 rows of curved teeth whose main function is to pick up on-the-ground logging residues. These residues are sheared against fixed knives. The purpose of the contract is: (a) to design, fabricate and test a mobile machine incorporating the RECUFOR concept; (b) to augment the comminution process by combining the RECUFOR with a conventional hog or chipper, to prepare the best material for storage, transportation and conversion.

DESCRIPTION

A.

1. To asses the various possible conceptual configurations for the RECUFOR and to select one for development.
2. To develop the design selected under (1) in sufficient detail that it can be efficiently manufactured and to prepare all necessary shop drawings and/or specifications for all components.
3. To manufacture one model of the machine according to the drawings and specifications of (2) above.
4. To execute shop and critical field tests with the machine of (3) above to ensure that it is free of major faults and to correct any such faults.

B.

1. The development of a design combining the RECUFOR with a conventional comminution device. A technical and economic feasibility analysis to be included.
2. Based on the design developed in (B.1), a program is to be proposed for the development and testing of an experimental prototype incorporating the RECUFOR.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$552,121			$552,121
1982-83	$163,910		$ 3,000	$719,031

REPORTS

STATUS AND COMMENTS

Sub-contract to Logging Development Corp. of Pointe Claire, Québec.
The work covered by the contract has been completed and a final report is expected by March 31, 1983. D.B.

83/04/26

PROJECT DATA SHEET # 233

TITLE	Soil Strength Measurements - Evaluation Study	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	31155-1-2674-D (OSX81-00132)	**DURATION**	January 1982 - June 1982
CONTRACTOR	Carleton University Department of Mechanical & Aeronautical Engineering Ottawa, Ontario K1S 5B6	**COST**	$25,180
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	J.Y. Wong Tele.: (613) 231-4317	**SCIENTIFIC AUTHORITY**	T.B. Golob National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tele.: (613) 993-1342

OBJECTIVE

To provide terrain strength parameters needed for the design and development of appropriate terrain-vehicle systems for planting and harvesting hybrid poplar plantations in Eastern Ontario.

DESCRIPTION

Terrain measurements will be made at two typical plantation sites in an area between Cornwall and Prescott, Ontario. The soil strength measurements will be made using a vehicle mounted Bevameter and will include:

a) pressure-sinkage relations;
b) shear strength;
c) moisture content;
d) grain size distribution of soils;
e) bulk density of the terrain.

The terrain data will be collected under three different soil moisture conditions. The results of the pressure-sinkage and shearing tests will be analyzed and evaluated using the computerized procedures developed by the Transport Technology Research Laboratory of Carleton University.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 3,140			$ 3,140
1982-83	$22,040			$25,180

REPORTS

Report was completed in June 1982.

STATUS AND COMMENTS

The Bioenergy Program of the NRCC intends to publish parts of the report late in 1983. T.B.G.
83/04/26

PROJECT DATA SHEET # 243

TITLE	Optimization of Terrain-Vehicle Systems in Agro-Forestry	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	31155-1-2674-E (OSX81-00161)	**DURATION**	February 12, 1982 to January 31, 1983
CONTRACTOR	M.G. Bekker 224 East Islay Street Santa Barbara, Ca. U.S.A. 93101	**COST**	$25,216
		SPONSOR	National Research Council
		SCIENTIFIC AUTHORITY	Theodore B. Golob National Reserch Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 (613) 993-1342
PRINCIPAL INVESTIGATOR	M.G. Bekker Tele.: (805) 996-3486		

OBJECTIVE

1. To outline the method of terrain-vehicle system evaluation, procedures and their validation.
2. To recommend optimized terrain-vehicle systems for two typical hybrid poplar plantation sites in Eastern Ontario.

DESCRIPTION

Phase I The scope of the study will pertain to a complete and general outline of the methodology considering:

1. Definition of parameters for measurements of soil properties and terrain surface from locomotion viewpoint;
2. Description and referencing of instrumentation for soil measurements developed in various countries;
3. Mathematical models of soil-vehicle relationship and semi-empirical algorithms for vehicle design-performance evaluation;
4. Validation of the above semi-theoretical approach through computations of several examples and case studies, including comparison of the results with experiments made with various sizes and types of tires;
5. Vehicle mobility optimization as outlined in the procedural charts and diagrams with the definition of environment and mission requirements based on engineering practices.

Phase II Soil-vehicle systems will be evaluated for two typical plantation soils at four different moisture contents and three vehicles with two variants of tires. The evaluations will include computation and optimization of the following parameters: 1) drawbar pull-slip; 2) slope climbing; 3) rudimentary power estimates; 4) rudimentary fuel consumption estimate; 5) vehicle envelope and weight.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$14,326			$14,326
1982-83	$10,890			$25,216

REPORTS

The reports have been completed, Part I on March 31, 1982 and Part II on January 31, 1983.

STATUS AND COMMENTS

The Bioenergy Program of the NRCC intends to combine parts of the two reports into a single publication late in 1983.

83/04/26

PROJECT DATA SHEET # 254

TITLE	The Design & Development of a Bundling Attachment for Poplar Harvester	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	KL012-1-0084 (OSS81-00121) P-201	**DURATION**	September 1981 - March 1983
		COST	$32,234
CONTRACTOR	Hovey & Associates Limited 2378 Holly Lane Ottawa, Ontario K1V 7P1	**SPONSOR**	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	B.J. Sutherland Great Lakes Forest Research Centre 1189 Queen Street Sault-Ste-Marie, Ontario

OBJECTIVE

To design and build a bundling attachment for a poplar harvester.

DESCRIPTION

1. The uppermost tie will be approximately 90 to 122 cm higher than the first tie and provision made to make it adjustable within that range (90 to 122 cm) to accommodate varying heights of whip material.

2. The device must be designed and built to withstand the vibration and shock loading associated with mobile off-road service.

3. In addition to the sketch designs suitable for prototype manufcture, detailed engineering drawings to enable possible future fabrication are to be provided upon or prior to project completion. These drawings must indicate how the bundling device is to be built into the harvester and any modification required to the harvester, if applicable.

4. The present production rate of the harvester is not to be affected.

5. The Contractor will undertake, within this contract, any adjustments or modifications subsequent to field testing near Kemptville, Ontario, under the supervision of the Scientific Authority or his representative.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$19,796			$19,796
1982-83	$11,438		$ 1,000	$32,234

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 260

TITLE	Industrial Design and Consultations - Harvesting Equipment Development	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	31155-2-2807 (OSX82-00053)	**DURATION**	July 1982 - March 1983
CONTRACTOR	School of Industrial Design Carleton University Ottawa, Ontario K1S 5B6	**COST**	$21,670
		SPONSOR	National Research Council
		SCIENTIFIC AUTHORITY	T. Golob National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tele: (613) 993-1342
PRINCIPAL INVESTIGATOR	Willem Gilles Tele: (613) 231-3858		

OBJECTIVE

To design controls and other items related to operator-machine interaction. Also, to serve in a consulting capacity in all aspects of industrial design during the design stage of the development of hybrid poplar harvesting equipment.

DESCRIPTION

Design will be provided for the position of override controls for the automatic poplar plantation harvesting attachment for the Versatile model 160 test tractor. Also, controls will be designed for the Grapple and Front End Piler Attachments for Holder A60 test tractor.

A design will be made for a limited swing of the operator's seat in the Holder tractor; this will improve operator comfort when using Grapple attachment for skidding bunches of trees.

A mounting arrangement for the field testing of the reciprocating cutting tool which is being developed will be designed in cooperation with the tool development contractor.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$21,670			$21,670

REPORTS

STATUS AND COMMENTS

Consultation with other developers continued through the fiscal year 1982-83. Industrial design drawings for the seat and controls of the Holder A60 tractor were made. A mock up of the harvesting attachment for the Versatile 166 test tractor was made as well as industrial design drawings for the controls and fenders.

83/04/27

PROJECT DATA SHEET # 261

TITLE	Development of a Singularizing Device for Poplar Cuttings	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	31155-2-2808 (OSX82-00091)	**DURATION**	August 1982 - March 31, 1983
CONTRACTOR	Timberland Equipment Limited P.O. Box 490 Woodstock, Ontario N4S 7Z2	**COST**	$56,870
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	A. Paladino Tele.: (519) 537-6262	**SCIENTIFIC AUTHORITY**	T. Golob National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342

OBJECTIVE

To develop a singularizing device that would separate individual poplar cuttings delivered from the mass magazine by means of a conveyor. This device will eventually become the main component of an automatic planter.

DESCRIPTION

The mechanism will provide means of conveying the cuttings from the mass storage magazine to a singularizing device that would separate the individual cuttings and drop them top up into a chute.

The development will also provide the optimum storage and handling magazine for direct feeding of the cuttings into the singularizing device.

The separation of individual cuttings is the most critical function in the development of an automatic planting system, because of a large variation in the diameters of poplar cuttings. The basic constraints are of a biological and economic nature.

The speed of the singularizing function is critical if used for planting high density plantations, which means that the device must be adjustable within several planting requirements.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$56,870			$56,870

REPORTS

STATUS AND COMMENTS

Building of the prototype was delayed. Some laboratory testing has been done in February and March 1983. T.B.G.

83/04/27

PROJECT DATA SHEET # 263

TITLE	Development of a Reciprocating Tree Cutting Tool	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	31155-2-2806 (OSX82-00075)	**DURATION**	August 16, 1982 to March 31, 1983
CONTRACTOR	J.D. Reed Machine Limited 53 Empey Street P.O. Box 188 Brantford, Ontario N3T 5M8	**COST**	$61,700
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	A. Maiste Tele.: (519) 753-3909	**SCIENTIFIC AUTHORITY**	T. Golob National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342

OBJECTIVE

To develop a reciprocating tree cutting tool for the harvesting of coppice grown hybrid poplar plantations as well as dense mini rotation single stem plantations. The tool will be eventually incorporated into a tractor mounted harvesting attachment.

DESCRIPTION

The reciprocating cutting bar will work like a high speed cross-cut saw. It will be powered by a hydraulic motor through a specially designed transmission where the rotary motion will be transformed into a reciprocating action. The cutting tool must have a sawing capacity to cut through a 12 cm poplar tree at a ground speed of 2.4 km/h. The cut must be close to the ground and smooth.

The hydraulic power will be supplied by a pump driven by the tractor power take off.

The initial field tests will take place during the early winter of 1982/83.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$61,700			$61,700

REPORTS

STATUS AND COMMENTS

Detailed design drawings have been made and the prototype was built by February 1983. The initial field tests were scheduled for the month of March 1983. T.B.G.

83/04/27

PROJECT DATA SHEET # 267

TITLE	Development of a Felling-Bunching Attachment	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	31155-2-2633 (OSX82-00061)	**DURATION**	July 19, 1982 to March 31, 1983
CONTRACTOR	Hyd-Mech Engineering Ltd. 39 Houser's Lane P.O. Box 1030 Woodstock, Ontario N4S 8A4	**COST**	$110,968
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	S. Jasinski Tele.: (519) 537-6751	**SCIENTIFIC AUTHORITY**	T. Golob National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tele.: (613) 993-1342

OBJECTIVE

To develop a farm tractor attachment that will harvest 5 year old single stem hybrid poplar plantations. The machine should cut, bunch and unload trees in a continuous, automatic operation at a ground speed of 2.4 km/h and harvest an average of 1,000 trees per working hour.

DESCRIPTION

This development project is a follow-up of a feasibility study completed in the fiscal year 1981-82. The harvesting attachment will be mounted on the loader arms of a Versatile model 160 test tractor. The harvester will be able to operate on the same face of the plantation on either side of the machine; it will prebunch and unload bunches of approximately 15 trees to the free side of the tractor. The trees will be cut with two circular saws; they will be prebunched and unloaded with a system of novel mechanisms powered by a hydraulic pump driven by the tractor power take off. The automatic control system will be provided with a manual override positioned near the operator. The initial field tests are planned for late fall and early winter of 1982, with further tests in plantations during the winter months of 1983. The field tests will continue during the fiscal year 1983/84.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$110,968			$110,968

REPORTS

STATUS AND COMMENTS

Detailed design drawings have been made and the prototype harvesting attachment has been built and is undergoing preliminary field tests during March 1983. T.B.G. 83/04/27

PROJECT DATA SHEET # 270

TITLE	Development of a Grapple Attachment & Design of a Front End Piler Attachment	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	31155-2-2641 (OSX82-00093)	**DURATION**	September 1982 to March 31, 1983
CONTRACTOR	Do-Tan Manufacturing Limited 15 Hatt Street Dundas, Ontario L9H 2G1	**COST**	$22,533
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	R.G. Doel Tel.: (416) 628-2241	**SCIENTIFIC AUTHORITY**	T. Golob National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342

OBJECTIVES

1. To design a Front End Piler attachment for small farm tractors that would pick up bunches of trees, take them to the road and load a semi-trailer.
2. To develop a Grapple attachment for small farm tractors capable of skidding prebunched trees to the roadside landing site.

DESCRIPTION

1. In the harvesting system that involves felling and prebunching of hybrid poplar trees we have a choice of picking the bunches with a Front End Piler and taking them to the roadside where they are either stored on roadside piles or loaded directly on semi-tractors. The loading function requires a relatively high reach to drop the bunches over the side stakes. The attachment should be capable of collecting and handling approximately 15 poplar trees with a 13 cm diameter.

2. The Grapple attachment was designed by Do-Tan Manufacturing Limited during the fiscal year 1981/82. The development and laboratory testing will take place during the fall of 1982 and the field testing is planned for the winter of 1982-83. The attachment will be tested on the Holder A60 test tractor by skidding bunches of 15 poplar trees to the roadside landing site.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$22,533			$22,533

REPORTS

STATUS AND COMMENTS

1. Detailed design drawings were completed in September 1982.
2. Grapple attachment has been built and field tested in December 1982. It is being further tested during March 1983. T.B.G.

83/04/27

PROJECT DATA SHEET # 293

TITLE	Design of a Harvester-Chipper-Conveyor-Storage System to Harvest Brushwood using the "Pallari Cutting Principle"	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collecting Technologies
CONTRACT #	KH405-2-0053 (05582-00081) P-231	**DURATION**	August 23, 1982 to March 31, 1983
		COST	$318,220
CONTRACTOR	ELMS Design Incorporated 647 Tomahawk Crescent Ancaster, Ontario L9G 3N2	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	B.J. Sutherland Great Lakes Forest Research Centre Canadian Forestry Service P.O. Box 490 Sault Ste. Marie, Ontario P6A 5M7 Tele.: (705) 949-9561
PRINCIPAL INVESTIGATOR	R.G. Elms		

OBJECTIVES

1. To design, based on the Pallari cutting principle, a harvesting-chipper-conveyor-storage system to harvest brushwood in Canada.
2. To identify a suitable, commonly available carrier onto which the brush harvester design described in (1) is to be incorporated.
3. To produce engineering detail and assembly drawings.

DESCRIPTION

1. Design of the harvesting-chipper head portion of the system on the Pallari concept using detail and assembly drawings of the Pallari.
   Incorporte a chipping unit into the harvesting head design. A conveyor system to remove the harvested and chipped material will be designed as an integral part of the harvester-chipper unit. Preliminary design work on a storage system.

2. Incorporate the brush harvester onto a carrier.

3. The contractor will provide detail and assembly drawings such that the prototype harvester-chipper-conveyor system may be fabricated by any competent fabricator in Canada. The unit will be designed as a continuously-progressing, swath cutting unit. The equipment must be designed to negotiate moderately rolling terrain.

   Other conditions to be taken into account are soil, soil moisture and drainage, and stand conditio..s. Surfaces ranging from very even to moderately uneven must be accommodated.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1982-83	$ 58,220		$ 4,000	$ 62,220
1983-84	$256,000			$318,220

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 344

TITLE	Optimization of the Shearing Action and Pick Up Efficiency of the RECUFOR Rotor	**PROGRAM IDENTIFICATION**	4.3.5 Biomass Planting, Harvesting and Collection Technologies
CONTRACT #	KH405-2-0199 (0SS82-00173)	**DURATION**	February 1, 1983 to June 30, 1983
CONTRACTOR	Forest Engineering Research Institute of Canada 143 Place Frontenac Pointe Claire, Québec H9R 4Z7	**COST**	$49,421
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	D. Brière, Manager Special Projects	**SCIENTIFIC AUTHORITY**	Mr. B.J. Sutherland Great Lakes Forest Research Centre Canadian Forestry Service Department of Environment P.O. Box 490 Sault Ste. Marie, Ontario P6A 5M7 Tel.: (705) 949-9461

OBJECTIVES

1. To optimize the RECUFOR rotor/impeller system based on the field test observations.
2. The proposed testing will be aimed at reducing shearing forces and solving problem areas observed during the field tests.
3. To execute the bench tests, analyse the result and produce a final arrangement of the RECUFOR rotor.

DESCRIPTION

Phase I The contractor will establish an experimental design for a series of bench tests to optimize the RECUFOR rotor/impeller system to:
(a) minimize the shearing forces required to process logging residues
(b) reduce the frequency with which residues are entering longitudinally into the rotor
(c) reduce jamming.

Phase II The contractor will conduct bench tests, analyse the test results and make a series of modifications to optimize the performance and efficiency of the rotor/impeller system.

Phase III Following completion of bench testing and data analysis the contractor will provide detail and assembly drawings of the optimized rotor/impeller assembly suitable to enable fabrication by any competent fabrication shop in Canada.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83 1983-84	$ 25,000 $ 24,421			$ 25,000 $ 49,421

REPORTS

STATUS AND COMMENTS

See Project #195 for previous work on RECUFOR.

83/04/29

BIOMASS CONVERSION TECHNOLOGIES

Biogas Production

Low Joule Gasification

Medium Joule Gasification

Methanol

Direct Combustion

Char Production

Oil Production - Liquefaction

Chemical Feedstocks

PROJECT DATA SHEET # 20

TITLE	Development, operation and demonstration of a farm scale anaerobic digester for production of methane from hog manure.	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Technology/Biogas Production.
		DURATION	October 5, 1977 to December 15, 1984
CONTRACT #	07SZ.01843-7-0752 (OSZ77-0152)	**COST**	$62,190
CONTRACTOR	John Fallis, RR#3, Millbrook, Ontario. L0A 1G0	**SPONSOR**	Agriculture Canada, Ottawa Ontario
PRINCIPAL INVESTIGATOR	John Fallis Tel.: (705) 932-5568	**SCIENTIFIC AUTHORITY**	R. Hocking Engineering & Statistical Research Institute Research Branch Agriculture Canada Bldg. 94 Ottawa, Ontario Tel.: (613) 995-9671

OBJECTIVE

To develop and operate a farm scale anaerobic digester for production of methane from hog manure.

DESCRIPTION

1. An anaerobic digester for the production of methane gas from hog manure based on the design produced by D. Young of Midwest Silos has been constructed.

2. The operation of the system using the manure from the 700-1500 hogs is being tested and monitored.

3. Collection and summary of data on temperature, gas production, energy inputs, loading rates, digestory effects, net yields of energy, and management of operational requirements will be detailed in the final report.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1977-78	$16,384			$16,384
1978-79	$ 8,976			$25,360
1979-80	$ 4,000			$29,360
1980-81	$ 4,000			$33,360
1981-82	$16,000			$49,360
1982-83	$12,830			$62,190
1983-84	-			$62,190

REPORTS

STATUS AND COMMENTS

Modifications have been completed to the mixing, loading and unloading systems. Safety standards at the site have been improved. The project continues to provide valuable information on the typical problems a farmer will encounter on a farm scale system. R.H.

83/04/18

PROJECT DATA SHEET # 114

TITLE	Study of the Upflow, Anaerobic Sludge Blanket Reactor for Methane Production from Food Processing Wastes	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Technology/Biogas Production
CONTRACT #		**DURATION**	1978-1983
		COST	$297,000
CONTRACTOR	National Research Council Rideau Falls Laboratory Sussex Drive Ottawa, Onttario K1A OR6	**SPONSOR**	Division of Biological Sciences, and Bioenergy Program (Liquid Fuels Task) National Research Council
PRINCIPAL INVESTIGATOR	L. van den Berg and K.J. Kennedy Tel.: (613) 992-3310	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

To evaluate and adapt the anaerobic upflow sludge blanket reactor, originally developed in the Netherlands for mostly soluble wastes, for Canadian wastes and conditions.

DESCRIPTION

Tests with upflow fixed film reactors showed that performance of these reactors is in fact in great measure due to the development of a very active sludge layer in the bottom part of the reactors. Recent tests have shown that methane production rates of over 5 m^3/m^3/day can be achieved with wastes suitable for this type of reactor, which was originally developed in the Netherlands and is in commercial use there. Work, now mostly completed has yielded information on engineering aspects of the process, on the type of wastes that can be used and on the advantages and disadvantages of the process in comparison with downflow fixed film reactors. This work may lead to full-scale application.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1978-79	$ 64,000			$ 64,000
1979-80	$118,000			$182,000
1980-81	$ 80,000			$262,000
1981-82	$ 20,000			$282,000
1982-83	$ 15,000			$297,000

REPORTS

Effect of Type of Waste on Performance of Anaerobic Fixed Film and Upflow Sludge Bed Reactors, by L. van den Berg, K.J. Kennedy and M.F. Hamoda, Biological Sciences, National Research Council of Canada, Ottawa, Ontario. K1A OR6. 1981 NRCC #19315.
(Available from authors)

Potential Use of Anaerobic Processes for Industrial Waste Treatment by L. van den Berg and K.J. Kennedy. 1981 NRCC #19727.
(Available from authors)

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 115

TITLE	Evaluation of downflow anaerobic fixed film reactors for methane production from wastes	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Technology/Biogas Production
		DURATION	1978-1984
CONTRACT #		**COST**	$881,000
CONTRACTOR	National Research Council Biological Fuels Laboratory Division of Biological Sciences Rideau Falls Building Ottawa, Ont. K1A 0R6	**SPONSOR**	Division of Biological Sciences, and Bioenergy Program (Liquid Fuels Task) National Research Council
PRINCIPAL INVESTIGATOR	L. van den Berg, K.J. Kennedy S. Duff & R.J. Samson Tel.: (613) 992-3310	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

To optimize reactor performance, to study methane production and pollution removal with citric acid waste, fish processing waste, dairy waste, masonite processing waste, pulping waste and stillage waste and to evaluate commercial film supports.

DESCRIPTION

Studies showed that methanogens attach themselves readily to solid supports and are not readily washed out. Once a film was formed on the support, it was not easily removed and was very active. These characteristics turned out to be very important for the performance of the downflow stationary fixed film (DSFF) reactor.

Many of the practical aspects of this reactor have now been studied in considerable detail. These include start-up phenomena, effects of support material on start-up and performance, effects of type and concentration of wa[illegible] and its nutrient content, and effects of temperature, reactor size and effluent recirculation. In addition, non-steady state effects, such as caused by rapid change over from ne waste to another, by hydraulic and organic overloading, by intermittent loading and by long periods of starvation were studied.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1978-79	$ 63,000			$ 63,000
1979-80	$118,000			$181,000
1980-81	$130,000			$311,000
1981-82	$170,000			$481,000
1982-83	$200,000			$681,000
1983-84	$200,000			$881,000

REPORTS

KENNEDY K.J. and VAN DEN BERG L., Anaerobic Digestion of Piggery Waste Using a Stationary Fixed Film Reactor. Agric. Wastes. 4, 151-158, 1982.

KENNEDY K.J. and VAN DEN BERG L., Thermophilic Downflow Stationary Fixed Film Reactors for Methane Production from Bean Blanching Waste. Biotechn. Letters 4, 171-176, 1982.

KENNEDY K.J. and VAN DEN BERG L., Stability and Performance of Anaerobic Fixed Film Reactors During Hydraulic Overloading at 10-35° C. Water Res. 16, 1391-1397, 1982.

KENNEDY K.J. and VAN DEN BERG L., Comparison of Intermittent and Continuous Loading of Stationary Fixed Film Reactors for Methane Production from Waste. J. Chem. Tech. Biotechn. 32, 427-432, 1982.

KENNEDY K.J. and VAN DEN BERG L., Effect of Substrate Composition on Methane Production Rates of Downflow Stationary Fixed Film Reactors. Proc. Symp. "Energy From Biomass and Wastes" - VI, 401-423, 1982.

STATUS AND COMMENTS

Results were confirmed in larger scale test in an industrial laboratory and at the Wastewater Technology Center in Burlington. Commercial scale systems are under construction. L.VDB 83/04/26

PROJECT DATA SHEET # 125

TITLE	Development of advanced anaerobic treatment technologies for the production of methane from waste	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Technology/Biogas Production
		DURATION	1979-1983
CONTRACT #		**COST**	$466,500
CONTRACTOR	Cooperative project of the Waste Water Technology Center of Environment Canada and the National Research Council	**SPONSOR**	Biological Sciences National Research Council
		SCIENTIFIC AUTHORITY	L. van den Berg Biological Sciences National Research Council Ottawa, Ont. K1A 0R6 (613) 992-3310
PRINCIPAL INVESTIGATOR	B.E. Jank, E. Hall and L. van den Berg		

OBJECTIVE

To develop a data base for comparison and process design for four advanced technologies: anaerobic filter, anaerobic fluidized bed reactor, upflow anaerobic sludge blanket reactor and fixed-film reactor.

DESCRIPTION

Phase I

Pilot plant studies will be carried out by Environment Canada at the Wastewater Technology Centre in Burlington in cooperation with NRC. These studies with about 1 m^3 reactors will evaluate the above mentioned technologies for the generation of fuel grade methane gas from industrial and municipal wastes. Data obtained during these studies will be used to assess the problems associated with scale-up and to establish an adequate information base for full scale process design.

Phase II

1. The development, testing and demonstration of an automated process monitoring and control package for high rate anaerobic reactors.

2. The identification of design and operational constraints on high rate anaerobic reactors for energy production, pollution control and unsteady state operation.

FUNDING

FISCAL YEAR	SPONSOR NRC	CONTRACTOR	ENVIRON. CANADA	CUMULATIVE TOTAL
1979-80	$20,000		$60,800	$ 80,000
1980-81	$77,200		$34,000	$191,200
1981-82	$68,000		$27,500	$276,900
1982-83	$76,600		$53,200	$406,500
1983-84	$60,000			$466,500

REPORTS

STATUS AND COMMENTS

The objectives of Phase I have been achieved and a final report will be filed. It was concluded that before an operational pilot plant can be promoted some work needs to be done on process controls. This will be part of Phase II study starting in 1983. L.VDB

83/04/14

PROJECT DATA SHEET # 211

TITLE	Anaerobic Digester Mixing Study	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
CONTRACT #	KE111-0-0290 (OSE80-00089)	**DURATION**	September 1980 to February 1983
CONTRACTOR	International Environmental Consultants 5233 Dundas Street W. Suite 410 Islington, Ontario M9B 1A6	**COST**	$245,780
		SPONSOR	Environment Canada, Ontario Min. of Natural Resources & Bioenergy Program of NRC
PRINCIPAL INVESTIGATOR	B.E. Jank	**SCIENTIFIC AUTHORITY**	Eric Hall Wastewater Technology Centre Environment Canada Box 5050, 867 Lakeshore Road Burlington, Ontario L7R 4A6

OBJECTIVE

It is evident from tracer studies that only a fraction of the available volume in existing digesters actually is being used. Thus many existing digesters are significantly oversized. This study proposes to determine the levels of mixing required to achieve the maximum rates of digestion.

DESCRIPTION

1. A full-scale study on the effects of mixing on digester performance will be carried out, since current theory does not allow reliable scale-up. One of the existing 16.8 m diameter primary digesters in Brantford will be used.

2. Initially mixing will be optimized to the normal loading rates of 2 $kg/m^3/d$. Following this higher loading rates will be employed to quantify the degree of improvement by mixing.

3. The Carter gas gun system will be used for mixing.

4. The following two groups of parameters will be monitored: a) indicators of performance: sludge volume, fixed and volatile solids, gas production and gas composition; b) digester environmental conditions: metals, temperature, pH, total nitrogen, and volatile acids.

5. Another digester will be used as an experimental control.

FUNDING

FISCAL YEAR	ENV SPONSOR	ONTARIO	N.R.C.	CUMULATIVE TOTAL
1980-81	$71,400	$20,200	$40,000	$131,600
1981-82	$ 5,700	$45,500	$20,500	$203,300
1982-83		$34,880	$ 7,600	$245,780

REPORTS

STATUS AND COMMENTS

At the completion of the Phase I studies, an interim report was submitted by IEC Ltd. After a final review by the project steering committee in November 1982, it was decided that problems with the tracer methodology had prevented an accurate evaluation of the mixing conditions in the Brantford digester. It was therefore recommended that the Phase II not be initiated and the contract was terminated at the completion of the Phase I portion of the study.

Environment Canada and the Ontario Ministry of the Environment have agreed to continue the study as a joint Federal-Provincial project. Ontario has undertaken further modifications to the digester to improve control over sludge volumes and flow. Environment Canada hs commenced a preliminary in-house study to verify an alternative approach to assessing digester mixing, prior to resuming the field studies at Brantford. E.H.

83/04/26

PROJECT DATA SHEET # 237

TITLE	Upgrading Waste Biomass into Methane Fuel Gas by Anaerobic Fermentation	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
		DURATION	3 years
CONTRACT #	Strategic Grant		
CONTRACTOR	Department of Chemical Engineering Waterloo University Waterloo, Ontario N2L 3G1	**COST**	$60,600
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	M. Moo-Young	**SCIENTIFIC AUTHORITY**	n/a

OBJECTIVE

In the proposed research, we plan to apply our previously-attained expertise in anaerobic digestion in order to develop a free-standing anaerobic fermentation process which will generate fuel gas as the main product. We intend to determine the solids conversion efficiency (liters gas produced/g solids added) and the concomitant gas generation rate for a range of agricultural and forestry wastes (separately and in combinations) which are widely available in Canada. The experimental work will be performed in existing demonstration units now being operated in our engineering analysis of the process energy budget for the various cases and to perform a detailed economic analysis of a number of scenarios pertinent to the types of raw materials available in representative regions of Canada.

DESCRIPTION

The work program is divided into four areas:
1) A state-of-the-art review of the relevant literature.
2) Design and construction of experimental equipment.
3) Experimental studies of co-digestion of manures and cellulosic residues, slected as grass, straw and corn stover.
4) Development and application of a computer program for processing economic evaluations.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$22,200			$22,200
1982-83	$22,200			$44,400
1983-84	$16,200			$60,600

REPORTS

Related publications

CHAHAL D.S., VLACH D., MOO-YOUNG M., Effect of physical and physicochemical pretreatments of wood for SCP production with C. cellulolyticum. Biotechnol. Bioeng. In press (Accepted March 1981)

MOO-YOUNG M., CHAHAL D.S., STICKNEY B., Pollution control of swine manure and straw by conversion to C. cellulolyticum SCP feed. Biotechnol, Bioeng. In press (Accepted March 1981).

MOO-YOUNG M., MACDONALD D.G., Improved economics of the Waterloo SCP process by increasing growth rates. Biotechnol. Letters, 3, 149-152 (1981).

GONZALEZ-VALDES A., MOO-YOUNG M., Production of yeast SCP from corn stover hydrolysates. Biotechnol. Letters, 3, 143-148 (1981).

STATUS AND COMMENTS

Working in collaboration with J.M. Scharer and C.W. Robinson. See project #38 for previous work under Strategic Grant 1978-1981.
The evaluations for agricultural wastes and crop residues are nearing completion and process design criteria are being established. The experimental research on forestry wastes have not yet started. Equipment is now in place to test the potential utilization of forestry residues for biogas production with concurrent pollution abatement of the wastes. 83/04/26

PROJECT DATA SHEET # 259

TITLE Feasibility Assessment of Biogas Generation by Anaerobic Fermentation of Pulp & Paper Wastes

CONTRACT # KN107-2-4146 (0SS82-00050)
C-300

CONTRACTOR ADI Limited
1115 Regent Street
P.O. Box 44
Fredericton, N.B.
E3B 4Y2

PRINCIPAL INVESTIGATOR Robert C. Landine
Tele.: (506) 454-4491

PROGRAM IDENTIFICATION 4.3.6.1
Biomass Conversion Technologies/Biogas Production

DURATION June 1982 - March 1983

COST $99,544

SPONSOR Environment Canada (ENFOR)

SCIENTIFIC AUTHORITY wm L. Morisset
National Research Council
Montreal Road
Building M-55
Room 381
Ottawa, Ontario
K1A 0R6

Tele.: (613) 993-1342

OBJECTIVES

1. To assess the performance of downflow and horizontal flow anaerobic filters in the treatment of settled sanitary wastewater through laboratory and pilot plant studies under both simulated (laboratory) dynamic operating conditions and actual (pilot) operating conditions. using wood and rock media.
2. To develop design criteria related to loadings, hydraulic retention time (HRT), biogas generation, and recycle rates for a full-scale anaerobic filter system.
3. To prepare conceptual designs of a few systems utilizing this treatment process and develop economic comparisons with conventional municipal wastewater treatment systems.

DESCRIPTION

Task 1 Perform a complete chemical analysis of the clarified wastewater from FACPP treatment plant.

Task 2 Construction of four bench scale anaerobic filters.

Task 3 Construction of two pilot scale filters at the FAPCC treatment plant.

Task 4 Start-up of the models, both bench-scale and pilot-scale, lasting probably 3-4 months for each model. To accelerate start-up, both bench and pilot will be heated to 35 and 25 °C, respectively.

Task 5 Operation of the stabilized models with routine monitoring and dynamic testing for a period of 9 to 12 months.

Task 6 Analyze operational data and compare:
a) performance of bench-scale DFF and HAF systems
b) compare the effect of the media; and
c) compare the performance of laboratory and pilot scale systems, rock and wood media.

Task 7 Based on analysis performed in Task 6, choose the system with the greatest potential and better performance characteristics.

Task 8 Prepare conceptual designs of a few systems using this pretreatment process, and develop economic comparisons with conventional municipal wastewater systems.

Task 9 Prepare a draft report documenting all the data, findings, cost, economic comparisons, energy savings, suggestions for further research, etc., for discussion and comments.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$99,544			$99,544

REPORTS

STATUS AND COMMENTS

83/03/03

PROJECT DATA SHEET # 285

TITLE	Demonstration of Fixed Film Anaerobic Reactor	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
CONTRACT #	DRECT	**DURATION**	3 years
CONTRACTOR	Agropur C.P. 6000 510 Principale Granby, Quebec J2G 7G2	**COST**	$1,658,000
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	Roeland H. Peters	**SCIENTIFIC AUTHORITY**	R.L. Christensen Waste Management Branch Environmental Proctection Service Place Vincent Massey 351 St. Joseph Blvd. Hull, Quebec K1A 1C8 Tele: (613) 997-4334

OBJECTIVE

1. Reducing BOD load of wastewater by 70% anaerobicaly and 98% over all.
2. Producing 1385 m^3/c methane gas to replace 1194 L. of imported #6 bunker C fuel oil.
3. Eliminating 7200 kWh/d of electrical energy consumption otherwise required to reduce BOD load aerobicaly.
4. Proving 97% BOD reduction with aerated lagoon under Canadian winter conditions.

DESCRIPTION

1. Engineering & Design

The contractor will design and build a unique wastewater treatment plant for dairy waste that will eliminate 7200 kWh/d of electrical energy consumption otherwise required for a standard aerobic system and also produce methane gas that will be burned to produce steam at a rate of 700 kg/h. The system will consist of two anaerobic fixed film reactors and other peripherals such as a solid screen, lagoons etc.

2. Construction & Installation

The contractor will construct the wastewater treatment plant on a piece of land to be purchased next to their cheese and whey powder process plant in Notre-Dame-du-Bon-Conseil. The land necessary to build the wastewater plant including the buffer zone to nearest residence is 16 ha. The construction will include: a pumping station with submersible pumps; primary treatment including a degritting channel, the equalization basin with mechanical mixers, and two anaerobic fixed film fermenters, two aerated lagoons, two polishing lagoons and an out fall to the Nicolet River.

3. Testing & Monitoring Program

Following successful completion of the start-up program, the plant shall undergo a 40 weeks performance monitoring program.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 88,000			$ 88,000
1982-83	$200,000			$ 288,000
1983-84	$ 37,500			$ 325,500
1981-83		$1,332,500		$1,658,000

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 286

TITLE Mobile Anaerobic Fixed-Film Reactor

CONTRACT #
1. 31028-1-2442 (OSC81-299)
2. 31028-2-2069
3. 31028-2-2788
4. 31028-2-2057
5. 31028-2-2561

CONTRACTOR
1. J.D. Koppernaes Eng. Ltd.
   Bedford, Nova Scotia
2. J.D. Koppernaes Eng. Ltd.
   Bedford, Nova Scotia
3. IMP
   Halifax, Nova Scotia
4. Wilson Trucks
   Truro, Nova Scotia
5. J.D. Koppernaes Eng. Ltd.
   Bedford, Nova Scotia

PRINCIPAL INVESTIGATOR
L. van den Berg
National Research Council

PROGRAM IDENTIFICATION 4.3.6.1
Biomass Conversion Tech./
Biogas Production

DURATION December 1981 - March 1983

COST $79,987

SPONSOR National Research Council
(Liquid Fuels Taks)

SCIENTIFIC AUTHORITY
D. Robson (Projects #1 - 4)
Atlantic Regional Laboratory
1411 Oxford Street
Halifax, Nova Scotia
B3H 3Z1

Tele: (902) 426-8271

L. van den Berg (Project #5)
Biological Sciences
National Research Council
Ottawa, Ontario
K1A 0R6

Tele.: (613) 992-3310

OBJECTIVES

1. Construct a mobile down-flow fixed film reactor and install in a mobile trailer.
2. Conduct research trials on waste from plants in the Maritime provinces, such as a cheese factory in Truro, N.S.

DESCRIPTION

Contract #1: Design of mobile anaerobic fixed film reactor
Contract #2: Project engineering for a prototype anaerobic digestion trailer
Contract #3: Supply a prototype model of a fixed film anaerobic reactor
Contract #4: Construct a prototype anaerobic digester trailer
Contract #5: Anaerobic waste treatment and energy recovery studies in the Maritime provinces using fixed film reactor facilities

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 7,827 design			$ 7,827
1982-83	$ 7,415 const.			$15,242
1982-83	$ 9,900 reactor			$25,142
1982-83	$40,445 trailer			$65,587
1982-83	$14,400 trials			$79,987

REPORTS

STATUS AND COMMENTS

The mobile research facility will be used at several factories to gain information on reactor performance under practical conditions, as well as to provide an opportunity to develop local expertise in an anaerobic technology.

83/04/27

PROJECT DATA SHEET # 287

TITLE	Anaerobic Digestion Control Equipment	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
CONTRACT #	31155-2-2852 (OSU82-00353)	**DURATION**	January 1983 to March 1983
CONTRACTOR	Industrial Technology Centre Manitoba Research Council 1329 Niakwa Road Winnipeg, Manitoba R2J 3T4	**COST**	$ 29,300
		SPONSOR	National Research Council (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	K.E. Thacher	**SCIENTIFIC AUTHORITY**	W.M. Lyse Morisset National Research Council Montreal Road Building M-55, Suite 381 Ottawa, Ontario K1A 0R6 Tele: (613) 993-1342

OBJECTIVE

The design development and fabrication of a preliminary prototype control system for an anaerobic digestion reactor for the production of methane from biomass.

DESCRIPTION

The development work shall involve the following:

a) Modification and streamling of the experimental software program developed by NRC in line with the above requirements.
b) Evaluation of the software using a model set up and inputs varying in accordance with known reactor behaviour.
c) Drawing up specifications for the prototype microprocesser and associated hardware.
d) Fabrication and assembly of preliminary prototype controller.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 29,300			$ 29,300

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 288

TITLE	Improving Production and Reliability of Methane Digesters	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
CONTRACT #	01843-1-ER16 (OSU82-00016)	**DURATION**	January 1, 1982 to December 1983
CONTRACTOR	University of British Columbia Dept of Bio-Resource Engineering 2075 Wesbrook Mall Vancouver, B.C. V6T 1W5	**COST**	$315,700
		SPONSOR	Agriculture Canada
PRINCIPAL INVESTIGATOR	K.V. Lo	**SCIENTIFIC AUTHORITY**	D. Marshall Engineering & Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671

OBJECTIVE

1. Investigate feasibility of increasing biogas production using advanced reactor concepts with liquid-solids separation pretreatment.
2. Develop design criteria for construction of on-farm scrubbers for removal of carbon dioxide and hydrogen sulfide from biogas.
3. To investigate the development of a pH and a methane sensor suitable for continuous monitoring of on-farm methane digesters.

DESCRIPTION

Project 1
Phase I To select the proper screen size for liquid-solid separation pretreatment based on optimum volatile solid levels and compare the rate of biogas production from various laboratory-scale and conventional reactors.
Phase II To evaluate the most promising reactors on a pilot scale and to produce design criteria for assessment of farm scale advanced concept reactors.
Project 2
Phase I To compare the effectiveness of various scrubbing systems and to develop design criteria for the development of an on-farm biogs scrubber.
Phase II To field test the scrubbers with pilot-scale digesters and to make the necessary modifications.
Project 3
Phase I To select, study and recommend a pH sensor suitable for continuous use in on-farm digesters and for digester control systems and develop a methane concentration sensor suitable for farm use.
Phase II To field test the pH and methane sensors with pilot-scale digesters.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 86,468			$ 86,468
1982-83	$155,292			$241,760
1983-84	$ 73,940			$315,700

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 289

TITLE	Design, Fabrication and Monitoring of a Complete Anaerobic Hog Waste Treatment System with Energy Recovery	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
DURATION			March 1982 to March 1985
CONTRACT #	01916-1-ER17 (OSZ82-00049)	**COST**	$323,718
CONTRACTOR	McLaren Engineers, Planners and Scientists Inc. 320 Adelaide Street South London, Ontario N5Z 3L2	**SPONSOR**	Agriculture Canada
		SCIENTIFIC AUTHORITY	D. Marshall Engineering & Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671
PRINCIPAL INVESTIGATOR			

OBJECTIVE

1. develop a design for hog waste treatment including gas storage and cleaning with an energy recovery system using the latest technology
2. construct and monitor a demonstration plant and to develop, in cooperation with a manufacturer of farm equipment, a packaged design to be marketed and made available to the hog industry. It will be a mesophillic process for a 700-hog operation.

DESCRIPTION

1. The contractor shall evaluate currently available anaerobic digester designs with specific reference to the following factors:
   a) Environmental Factors 1) pH; 2) alkalinity; 3) volatile acid concentrations; 4) temperature; 5) nutrient availability; 6) toxic materials.
   b) Operational Factors 1) composition of organic substrate; 2) retention time; 3) concentration of substrate; 4) organic loading rate; 5) degree of mixing; 6) heating and heat balance; 7) concentration of effluent; 8) nutrients in effluent; 9) sensitivity to hydraulic, temperature and loading irregularities.
2. The contractor shall complete a detailed design including a detailed cost estimate and economic evaluation including the potential for recovery of protein from the waste.
3. The contractor shall ensure the construction of an anaerobic waste treatment facility as developed in stage 1 and 2 adjacent to existing hog barns.
4. The contractor shall operate and monitor the facility and prepare a final report detailing the design, construction and performance of the system.
5. The contractor is to prepare a report outlining design requirements for a packaged system, using data and design parameters obtained in the demonstration plant work in phase 4.

A packaged system based on the demonstration plant design would be prepared complete with an economic evaluation, energy balance and overall treatment efficiency assessment. The package system could then be marketed through the joint venture company which would combine the engineering equipment supply and marketing expertise from the proponents.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 86,468			$ 86,468
1982-83	$149,283			$235,751
1983-84	$ 68,600			$304,351
1984-85	$ 19,367			$323,718

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 309

TITLE	The Design of a Digester for Pig Manure	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
CONTRACT #	01843-1-ER15 (OSD81-00178)	**DURATION**	1 year
CONTRACTOR	Centre de Recherche Industrielle du Québec 333 rue Franquet C.P. 9038 Ste-Foy, Québec G1V 4C7	**COST**	$100,739
		SPONSOR	Agriculture Canada
		SCIENTIFIC AUTHORITY	Roger Chagnon Agriculture Canada Station de Recherche de St-Jean 90 Lajeunesse, C.P. 457 St-Jean, Québec J3B 6Z8 Tel.: (514) 346-4494
PRINCIPAL INVESTIGATOR	Denis Morrissette		

OBJECTIVE

To develop a prototype anaerobic digester using the advanced systems design of NRC and the techniques and materials of CRIQ and to establish their costs.

DESCRIPTION

1. Final design of a 50-60 m^3 anaerobic digester.
2. Select the fixed film material.
3. Select a coarse screen for filtering the solids.
4. Select a system for gas storage and utilization.
5. Review the safety regultions.
6. Select a control system.
7. Prepare a flow sheet and include instrumentation.
8. Prepare a mass and energy balance.
9. Write an experimental program.
10. Select a system for solid/liquid separation permitting the maximum recovery of proteins.
11. Identification of a process for forage supplement preparation.
12. Definition of analyses necessary for the evaluation of its potential.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$100,739			$100,739

REPORTS

1st part of contract
MORRISSETTE D., DESILETS P., DUGAL F., Centre de Recherche Industrielle du Québec, The Design of a Digester for Pig Manure. Ste-Foy, Québec, December 1982.

STATUS AND COMMENTS

Scope of the work was enlarged to include: the on-site testing of a 0.5 m^3 NRC type reactor; and the development and fabrication of fixed film support materials. R.C. 83/04/29

PROJECT DATA SHEET # 319

TITLE	Biological Process Application for Biogas Production and Waste Treatment	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
CONTRACT #	Strategic Grant	**DURATION**	3 years
		COST	$122,400
CONTRACTOR	University of British Columbia Bio-Resource Eng. Dept. Vancouver, B.C. V6T 1W5	**SPONSOR**	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	Kwang Victor Lo	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

The overall objective of the proposed research is to develop an efficient integrated biogas production and waste treatment system for wet biomass such as animal manures and food processing wastes.

DESCRIPTION

1. To develop an efficient liquid-solid separator that is capable of providing a liquid manure filtrate with optimal volatile solids content for efficient biogas production;
2. To investigate the feasibility of significantly increasing biogas production per unit volume of digester through the use of the advanced reactor concepts (fixed film reactor (NRC)), fluidized bed reactor (Dorr-Oliver), etc.)preceded by liquid-solid separation of the feed stock;
3. To study the feasibility of combining a thermophilic aerobic digester and a mesophilic anaerobic digester for more efficient biogas production and animal waste treatment;
4. To process the thermohpilically digested solids for animal feed recovery;
5. To develop a microprocessor assisted control and monitoring system for animal manure treatment and biogas production.

Incorporating the components above, we are confident that a highly efficient and reliable biogas production and waste treatment system with feed recovery could be developed.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$39,000			$ 39,000
1983-84	$42,000			$ 81,000
1984-85	$41,400			$122,400

REPORTS

1. LO K.V. et al, The Effect of Solid-Separation Pretreatment on Biogas Production from Dairy Manure. 1983 (Manuscripts accepted for publication in Agricultural Wastes)
2. LO K.V. et al, Methane Production from Screened Dairy Manure Using A Fixed-Film Reactor. 1983 (Manuscripts submitted to Agricultural Wastes)

STATUS AND COMMENTS

Working in collaboration with N. Ross Bulley, Bio-Resource Engineering Dept. K.V.L.

83/04/29

PROJECT DATA SHEET # 342

TITLE	Development of Computer Control System for Anaerobic Reactors	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
		DURATION	2 years
CONTRACT #		**COST**	$70,000
CONTRACTOR	National Research Council Division of Biological Sciences 100 Sussex Drive Ottawa, Ontario K1A OR6	**SPONSOR**	NRC Division of Biological Sciences & Bioenergy Program
		SCIENTIFIC AUTHORITY	N/A
PRINCIPAL INVESTIGATOR	M.F. Prodruzny		

OBJECTIVE

To develop a micro-computer package suitable for industrial use and capable of controlling reactors under most operating conditions and of alerting operators of problems outside its control.

DESCRIPTION

Advanced anaerobic digestion processes with rapid production of methane are becoming recognized as an economical method of waste stabilization for industrial and farming applications. However, the methods of control of these fast processes demand, at present, the availability of expensive analytical equipment and highly trained technical staff. Neither equipment nor staff may be available under many conditions, and this would severely limit application of advanced and novel technologies.

To alleviate the need for analytical equipment and trained staff a computer control system is being developed. Since gas production is a very sensitive indicator of digester performance and can be measured readily, it was chosen as the controlled variable and feed rate as the manipulated variable. The main aim of the project is to develop a package that would under most operating conditions maintain the performance of the process and in the event of a severe upset would signal that a problem existed to allow remedial action to be taken.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 50,000			$ 50,000
1983-84	$ 20,000			$ 70,000

REPORTS

PODRUZNY M.F. and VAN DEN BERG L., Development of a computer control system for anaerobic methane producing reactors. Biotechn. Bioeng. Submitted for publication.

STATUS AND COMMENTS

The computer program was developed and tested in the laboratory and is being further modified and tested under contract with the Manitoba Research Council (Project #287) to arrive at a commercially useful prototype package. The prototype will be tested in the mobile reactor in the Maritimes (Project #286) M.F.P. 83/04/29

PROJECT DATA SHEET # 343

TITLE	Anaerobic Fixed Film Development and Performance	**PROGRAM IDENTIFICATION**	4.3.6.1 Biomass Conversion Tech./ Biogas Production
CONTRACT #		**DURATION**	1982 - continuing
		COST	$125,000
CONTRACTOR	National Research Council Division of Biological Sciences 100 Sussex Drive Ottawa, Ontario K1A OR6	**SPONSOR**	Division of Biological Sciences & Bioenergy Program National Research Council
		SCIENTIFIC AUTHORITY	N/A
PRINCIPAL INVESTIGATOR	K.J. Kennedy L. van den Berg		

OBJECTIVE

To optimize microbial film performance through a better understanding of film development and to determine effects of waste composition, recirculation and temperature on film formation and kinetics.

DESCRIPTION

Several basic questions were raised during the last few years of research on the development of the fixed film reactor into a commercially attractive system. These questions can only be answered by in-depth studies of the reactor. These studies are now underway and involve a detailed look at film development, a study of ecological developments in the film, and precise measurements of mixing in single and multichannel reactors, in relation to rector performance. Matnematical models to describe and predict reactor performance are being developed and localization of acid and methane production has been demonstrated. The work will continue to increase our understanding of fixed film reactors and to assist in developing improved reactors and assessing performance of other reactors such as the upflow sludge blanket reactor. The latter reactor was studied in some detail by a post graduate student (Project #114) and is also being installed now commercially in Canada.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 60,000			$ 60,000
1983-84	$ 65,000			$125,000

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 175

TITLE	Conversion of Cellulose to Ethanol Using a Two Stage Process	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Technology/Fermentation to Alcohol
CONTRACT #	LK229-1-4115 (OSS81-00032) C-181	**DURATION**	May 1981-March 1983
		COST	$183,580
CONTRACTOR	Forintek Canada Corporation Eastern Laboratory 800 Montreal Road Ottawa, Ont. K1G 3Z5	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	C.R. Mackenzie National Research Council Rideau Falls Laboratory Ottawa, Ontario K1A 0R6
PRINCIPAL INVESTIGATOR	J.K. Shields		

OBJECTIVE

1. To compare the cellulase enzyme systems of Trichoderma reesei C30 and the highly cellulolytic Trichoderma strains present in the Forintek culture collection.
2. To continue to screen for highly cellulolytic fungi present in the collection. To develop the production of a cellulase mixture which can convert cellulose to glucose fast and efficiently.
3. To establish a two-stage process of producing ethanol from cellulose. First, by converting cellulose to glucose using the best enzyme mixture. Secondly, converting the liberated glucose to ethanol using a high ethanol producing and ethanol tolerant Saccharomyces.
4. To scale this procedure up to a continuous process using a variety of different cellulosic substrates.

DESCRIPTION

1. Production of cellulase enzymes

a) Growth of 3 different cellulolytic fungi; b) Determine optimum conditions for growth and enzyme production; c) Assay for enzyme activity using filter paper, endoglucanase and B-glucosidase assay methods; d) Determine growth and enzyme production of fungi, grown on different pretreated substrates; e) Establish storage methods for retaining activity of cellulase enzymes prior to addition to ethanol production step; f) Enzymatic hydrolysis of different pretreated wood substrates and commercially available substrates assaying for reducing sugars and glucose.

2. Growth of ethanol producing Saccharomyces

a) Growth of 2 different Saccharomyces strains;
b) Assay for ethanol production from glucose;
c) Develop assay methods for ethanol using programable gas chromatograph;
d) Assay for utilization of reducing sugars and glucose;
e) Establish optimum conditions for ethanol production.

3. Establishing two stage system

a) Production of enzyme preparation which can convert cellulose to glucose;
b) Establish simultaneous saccharification and fermentation with enzymatic hydrolysis and ethanol fermentation of the cellulose derived glucose;
c) Assay efficiency of conversion of cellulose to glucose, glucose to ethanol.

4. Preliminary tests to scale the optimum methods up to the mini-pilot plant level using a 30 litre fermenter. Attempt semi-continuous production of ethanol from cellulose.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 86,223			$ 86,223
1982-83	$ 97,357			$183,580

REPORTS

STATUS AND COMMENTS 83/04/26

PROJECT DATA SHEET # 176

TITLE	Liquid Fuel Production from Hemicellulose	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Technology/Fermentation to Alcohol
CONTRACT #	KL229-1-4116 (OSS80-00033) C-187	**DURATION**	April 1981-March 1983
CONTRACTOR	Forintek Canada Corporation Eastern Forest Products Lab. 800 Montreal Road Ottawa, Ont. K1G 3Z5	**COST**	$154,348
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	J.K. Shields	**SCIENTIFIC AUTHORITY**	I. Veliky National Research Council Biological Sciences Sussex Drive Ottawa, Ont. K1A OR6

OBJECTIVE

The aim is to produce hemicellulose, hydrolyse it and to ferment the released sugars by aerobic and anaerobic organisms.

DESCRIPTION

1. To isolate and identify the hemicellulose fraction from a variety of different wood substrates and to compare the efficiencies of direct extraction or extraction following pretreatment.
2. To compare the relative efficiencies of chemical and enzymatic hydrolysis of hemicellulose fractions and to establish analytical methods for determining the degree of hydrolysis. To achieve conditions for chemical hydrolysis which allow maximum release of the composite monosaccharides without degrading these liberated sugars. To establish an enzyme system which will actively degrade all of the various hemicellulose fractions.
3. To optimize the production of solvents from hemicellulose derived sugars by anaerobic bacteria and to initiate studies to decrease the butanol toxicity of some of these microbes.
4. To optimize the production of butanediol and ethanol by aerobic bacteria grown on hemicellulose and cellulose-derived sugars and the establishment of continuous culture conditions.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$58,683			$ 58,683
1982-83	$95,665			$154,348

REPORTS

STATUS AND COMMENTS

83/04/14

PROJECT DATA SHEET # 236

TITLE	Development of an Economical Fermentation Process for the Production of Organic Solvents from Biomass	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
		DURATION	3 years
CONTRACT #	Strategic Grant		
		COST	$185,000
CONTRACTOR	Department of Microbiology Queen's University Kingston, Ontario K7L 3N6	**SPONSOR**	Natural Sciences and Engineering Research Council
		SCIENTIFIC AUTHORITY	n/a
PRINCIPAL INVESTIGATOR	A.M. Kropinski		

OBJECTIVE

Studies will concentrate on the development of genetically ameliorated bacterial strains which can ferment polymeric carbohydrates into alcohols and other useful compounds in unprecedented yields. The present limitation on solvent production with these organisms appears to be a result of end-product toxicity. Therefore, mutants displaying tolerance to fermentation end-product and insensitivity to intra- and extra-cellular phage and bacteriocins will be developed and exploited. This approach should afford solvents in much higher yields.

DESCRIPTION

The proposed research will concentrate on the development of genetically ameliorated bacterial strains which can tolerate high solvent concentrations. Three facets of the project and the suggested experimental approaches are outlined below.

1) The isolation of cellulose-, hemicellulose- and starch-degrading Clostridium strains and examination of culture supernatants for alcohols and other industrially useful chemicals.
2) The selection of mutant strains exhibiting increased tolerance to butanol.
3) The isolation of phage-resistant and nonbacteriocinogenic (or non-lysogenic) cultures.

Further specific studies will involve:

1) Selection of mutants with increased levels of starch/cellulose degrading enzymes. With the recent observation that C. acetobutylicum possesses carboxymethylcellulase and cellobiase activity this aspect of the project demands renewed attention. Whereas this organism is unable to degrade native cellulose it has been established that C. acetobutylicum can attack acid-swollen cellulose.
2) Selection of strains which produce solvents in different proportions.
3) The application of microbial genetics and recombinant DNA technology to strain improvement, initially involving the transfer of cellulose-degrading capacity by interspecies transformation using DNA from C. thermocellum or a related cellulose-degrading organism.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$65,000			$ 65,000
1982-83	$60,000			$125,000
1983-84	$60,000			$185,000

REPORTS

STATUS AND COMMENTS

83/03/02

PROJECT DATA SHEET # 246

TITLE	Evaluation of D-xylose Fermenting Yeasts on Wood Hydrolysates	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
		DURATION	December 1981 - July 1982
CONTRACT #	31155-1-0673/382 (OSX81-00102)	**COST**	$83,347
CONTRACTOR	Diversified Research Laboratories Limited 1047 Yonge Street Toronto, Ontario M4W 2L3	**SPONSOR**	National Research Council PILP
		SCIENTIFIC AUTHORITY	H. Schneider National Research Council Sussex Drive Ottawa, Ontario K1A OR6 Tele.: (613) 992-6512
PRINCIPAL INVESTIGATOR	G.R. Lawford		

OBJECTIVE

To adapt selected NRC yeast strains to growth on hydrolysed wood substrates, and to select those strains that convert the xylose component to alcohol.

DESCRIPTION

1. Yeasts will be evaluated/screened for their ability to produce alcohol from wood hydrolysates based on theoretical maximum alcohol yield.
2. Determination of amount and rate of alcohol produced by various strains of Pachysolen tannophilus and other xylose fermenting yeasts after acclimatization to wood hydrolysates.
3. Analysis of poly-alcohol during the course of fermentation experiments.
4. Evaluation of strain tolerance to various concentrations of wood hydrolysate and to high alcohol and sugar concentrations.
5. Evaluation of alcohol production and increased biomass levels (recycling).

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$73,667			$73,667
1982-83	$ 9,680			$83,347

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 248

TITLE	Production of Alcohol from Spent Sulfite Liquor Using NRC Pentose Fermenting Yeast	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
		DURATION	October 1981 - October 1983
CONTRACT #	Contribution Agreement CA155-1-0615/303B	**COST**	$275,456
		SPONSOR	National Research Council PILP
CONTRACTOR	Tembec Inc. Temiscaming, Québec J0E 3R0	**SCIENTIFIC AUTHORITY**	H. Schneider National Research Council Ottawa, Ontario K1A 0R6
PRINCIPAL INVESTIGATOR			Tele.: (613) 992-6512

OBJECTIVE

To develop a fermentation system using NRC xylose fermenter for the conversion of spent sulfite liquor to alcohol.

DESCRIPTION

1. Analysis of spent sulfite liquor (SSL) from soft and hardwoods to determine theoretical maximum alcohol obtainable.
2. Determine the amount of ethanol obtainable with brewer's yeast (for standard reference).
3. Determine amount of ethanol obtainable from strains of P. tannophilus from SSL.
4. Sugar analysis of the fermentation broth to determine species and amounts of sugars utilized.
5. Screen xylose fermenting yeasts.
6. Strain improvement by mutagenesis and selective crossing.
7. Optimization of the process.
8. Pilot scale operation.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 14,114	$ 4,738		$ 18,852
1982-83	$ 42,342	$14,214		$ 75,408
1983-84	$129,000	$71,048		$275,456

REPORTS

STATUS AND COMMENTS

82/04/13

PROJECT DATA SHEET # 269

TITLE	Development of Low Cost Process for Ethanol Recovery	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #	31155-2-2843 (ΔSX82-00142)	**DURATION**	November 1982 to November 1983
CONTRACTOR	Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario L5K 1B3	**COST**	$102,732
		SPONSOR	National Research Council (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	John D. Sheppard	**SCIENTIFIC AUTHORITY**	W.M. Lyse Morisset National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tel.: (613) 993-1342

OBJECTIVE

To determine the vapour-liquid equilibrium relationships of aqueous ethanol solutions in an efficient gas/liquid contactor and investigate the influence of selected solvents on this equilibrium. Subsequently, to determine the economic feasibility of utilizing such a process for low cost recovery of biomass-derived ethanol.

DESCRIPTION

Construct a bench scale (20 litre) gas/liquid contactor based on a energy efficient airlift principle.

Determine vapour-liquid equilibrium data for aqueous ethanol solutions at various temperatures, pressures and ethanol concentrations in the gas/liquid contactor.

Investigate the influence of selected organic solvents on these equilibrium relationships.

Evaluate an ethanol recovery system utilizing a selected solvent and the gas/liquid contactor for processing actual fermentation beer.

Correlate these results with those obtained on pure ethanol solutions.

Perform an economic feasibility study of such a process and compare to conventional distillation.

Give recommendations for future research or a strategy for commercialization.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 40,000			$ 40,000
1983-84	$ 62,732			$102,732

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 278

TITLE	Comparison of Free & Immobilized Cell Fermentation to Fuel Alcohol	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #	01916-2-EL14 (OSU82-00021)	**DURATION**	April 27, 1982 to March 31, 1984
CONTRACTOR	University of Western Ontario Stevenson-Lawson Building Room 101 London, Ontario N6A 5E8	**COST**	$309,248
		SPONSOR	Agriculture Canada (Liquid Fuels Task)
		SCIENTIFIC AUTHORITY	E. Delaroche Engineering & Statistical Research Institute Research Branch Agriculture Canada K.W. Neatby Building Ottawa, Ontario K1A 0C6 Tel.: (613) 995-3700
PRINCIPAL INVESTIGATORS	A. Margaritis N. Kosaric Dept. of Chemical & Biochemical Eng.		

OBJECTIVE

To develop advanced systems for alcohol production.

DESCRIPTION

1. To screen micro-organisms (yeasts and bacteria) on their capability to ferment potato culls, cheese whey, Jerusalem artichokes, fodder beets and lignocellulosic substrates at a high rate and yield of alcohol production.

2. To develop scaled up immobilized and free cell continuous fermentation systems in parallel that are comparable on a rate capacity basis. Reactor volumes will be at least 10 L. Variations of the systems will be tested to optimize alcohol productivity.

3. To evaluate enhancement/treatment methods for stillage or fermentat on byproducts of both immobilized and free cell systems to increase their value, reduce pollution load, facilitate materials handling, etc.

4. To perform an overall economic feasibility analysis of the two continuous systems at scales of production of 1 ML/a and 50 ML/a. The analysis will include engineering process designs, cost/equipment specifications and sensitivity to feedstock costs, fuel costs, etc. in sufficient detail to allow for a choice for eventual production facilities.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$148,676			$148,676
1983-84	$160,572			$309,248

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 283

TITLE	Characterization of a Pilot Scale Adsorbed Cell Bioreactor for Ethanol Production	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #	31155-2-2850 (OSU82-00346)	**DURATION**	December 1982 to December 1983
CONTRACTOR	Queen's University 131 Union Street Kingston, Ontario K7L 3N6	**COST**	$21,807
		SPONSOR	National Research Council (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	A.J. Daugulis	**SCIENTIFIC AUTHORITY**	W.M. L. Morisset National Research Council Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342

OBJECTIVE

To evaluate the technical feasibility of adsorbed cell bioreactors and determine the scale-up potential of such a reactor for ethanol production.

DESCRIPTION

To design and construct a column bioreactor 2 m in length which will utilize adsorbed whole cells for the continuous production of ethanol.

To install and integrate ancillary equipment used for operation of the reactor.

To operate the system at realistic substrate concentrations for extended periods of time.

To evaluate the performance of the system, propose possible design improvements, and assess the technical feasibility of the system for larger scale use.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$14,000			$14,000
1983-84	$ 7,807			$21,807

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 316

TITLE	Development of a System for Automatically Denaturing Ethanol Destined for Fuel Purposes	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Converstion Tech./ Fermentation to Alcohol
CONTRACT #	01843-1-EL03 (OSZ81-00134)	**DURATION**	February 5, 1982 to February 28, 1983
		COST	$21,010
CONTRACTOR	Wellington Engineering Ltd. 29 Hickory Street Guelph, Ontario N1G 2X2	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	E. Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671

OBJECTIVE

DESCRIPTION

A method or system that automatically denatures ethanol destined for fuel purposes is required. The method or system must be tamper-proof and/or be an inherent component of the production system. The denaturing system must not be able to be bypassed. It is preferred that the ethanol/water separation system cannot operate unless the denaturing system is functioning. The ethanol must be denatured before it reaches the receiver.

A method or methods applicable to various separation systems such as distillation, membrane separation, solvent extraction, freeze concentration, molecular seive, etc. should be considered.

It is intended to develop a method or system that will render the alcohol exempt from the requirements needed for beverage alcohol.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$21,010			$21,010

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 317

TITLE	Assessment of the Production of Alcohol in Two Phase Systems	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #	01843-1-EL13 (OSZ82-00041)	**DURATION**	June 1982 - August 1983
		COST	$81,690
CONTRACTOR	Gemini Biochemical Research Limited 3650 - 21st Street N.E. Calgary, Alberta T2E 6V6	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	Ian Forrester Tel.: (403) 285-8565	**SCIENTIFIC AUTHORITY**	Mr. J.E. Knipfel Research Station Research Branch Agriculture Canada Swift Current, Saskatchewan S9H 3X2 Tel.: (306) 773-4621

OBJECTIVE

DESCRIPTION

Phase I Determination of the ability of a second phase to partition various alcohol solutions from the aqueous phase from the standpoints of rate, efficiency or uptake and release, and energy requirements for regeneration.

Work shall be at lab scale using the following liquids for testing: (1) acetone, (2) butanol, (3) ethanol.

Phase II Examination of the interaction between the second phase and alcohol producing organisms during fermentation.

Work shall involve flask trials where active microbes are producing alcohol and other byproducts.
Parameters to be monitored include: (1) organism viability over time; (2) organism growth; (3) alcohol yields; (4) second phase viability and seperability; (5) second phase life expectancy; (6) economics and energetics of such a system.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$69,386			$69,386
1983-84	$12,304			$81,690

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 332

TITLE	Process Engineering of Solvent Extraction Coupled Fermentations for Product Recovery	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Converison Tech./ Fermentation to Alcohol
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	Queen's University Dept. of Chemical Engineering Kingston, Ontario K7L 3N6	**COST**	$105,000
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	Andrew J. Daugulis		

OBJECTIVES

1. To increase the productivity of conventional and non-conventional fermentation bioreactor configurations. This will be achieved by minimizing end product inhibition and increasing the ease of product recovery. Products under investigation are ethanol, phenol, aromatic acids and a polysaccharide, but application is envisaged to encompass other fermentation processes for producing industrial chemicals (e.g. acetone, butanol, butanediol).
2. To design, construct, operate and control continuous bioreactors which incorporate liquid-liquid extraction stages (internal or external). The extraction phase will be either hydrophilic or hydro-phobic depending on the product to be recovered.
3. To estimate the important engineering parameters for understanding the limitations of the system and the design criteria for large scale equipment.
4. To transfer this information to relevant commercial enterprises.

DESCRIPTION

I - Conventional System It is proposed to examine the conventional CSTR ethanol fermentation process as a model system for integrating product separation with bioreactor design in an extraction coupled fermentation process. This will be done as follows:

1) A suitable extracting solvent must be found.
2) A preliminary evaluation of the solvent fermentation system must be performed. Continuous operation on a small scale and over a reasonable length of time (one week) will determine such things as: compatability of the solvent with microbial cells, possible detrimental solvent-cell interfacial phenomena, long term phase stability, stability of the liquid-liquid interface subject to continuous gas passage; and suitability of analytical techniques. By the end of this phase of the work, the most effective solvent, and preliminary process operating conditions, will have been identified.
3) The technical design of a continuous solvent extraction coupled fermentation process with continuous product recovery will be formulated. The design will incorporate an effective solvent contacting system, solvent-product removal system, and a continuous product recovery arrangement with solvent recycle. These aspects will be integrated into an overall design, and a suitable monitoring and control system will be devised. The performacne characteristics and stability of the process will be evaluated by operating the system over a reasonable length of time (one to two weeks), and possible improvements made.
4) The techno-economic aspects of the process will be examined. It is important to investigate the suitability of the process to scale-up, the economic feasibility of the process relative to conventional ethanol fermentations, and the potential applicability of the process to other CSTR fermentations requiring continuous product removal.

II - Non-Conventional Systems The two non-traditional model systems to be investigated are a solid state fermentation utilizing filamentous fungi for the production of phenols and aromatic acids from lignocellulosic substrates, and a packed bed immobilized cell system using *Aureobasidium polulans* for the production of the polysaccharide, pollulan.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$35,000			$ 35,000
1982-83	$35,000			$ 70,000
1983-84	$35,000			$105,000

REPORTS

STATUS AND COMMENTS

Working in collabortion with Dr. D.H. Bone, Dr. R.H. Clark, Dept. of Chemical Eng. A.J.D. 83/04/29

PROJECT DATA SHEET # 338

TITLE	Development of Film Reactors Applicable to Ethanol Production	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
		DURATION	3 years
CONTRACT #	Strategic Grant		
CONTRACTOR	Carleton University Dept. of Microbiology Ottawa, Ontario K1S 5B6	**COST**	$96,000
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	H. Yamazaki	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

DESCRIPTION

Using the film fermenter, we are examining two methods of ethanol production from the Jerusalem artichoke tuber. The first method is acid hydrolysis of the tubers followed by fermentation of the resulting fructose by films of Saccharomyces cerevisiae and Zymomonas mobilis. The second method is hot water extraction of inulin followed by inulin fermentation by films of Kluyveromyces marxianus or K. fragilis. These yeasts have been shown to produce ethanol from inulin.

For both methods, adsorption of the ethanol producing microorganisms onto various films will be studied, and ethanol production will be compared. Ecteola paper is no longer commercially available. Since its preparation requires a series of washes and paper is fragile, we are making Ecteola cotton cloth which is as effective as Ecteola paper in the fermenter. We shall prepare other anion-exchangers: polyethylenimine-, diethylaminoethyl-, dimethylaminoethyl- and triethylaminoethyl cotton cloths and compare their performance as films in the fermenter.

We shall design a film fermenter which permits continuous operation since this will increase the ethanol production rate. A multilayer of films sandwiched between screens will be inserted into a horizontally placed cylinder.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$32,000			$32,000
1983-84	$32,000			$64,000
1984-85	$32,000			$96,000

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 350

TITLE	Development of a Flexible Farm-Scale Fuel Alcohol Production System	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #	01843-1-EL01 (OSZ81-00085)	**DURATION**	1981 - 1984
		COST	$243,730
CONTRACTOR	474706 Ontario Limited R.R. #3 Watford, Ontario NOM 2S0	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	G. Grewe	**SCIENTIFIC AUTHORITY**	E. Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Building #94 Central Experimental Farm Ottawa, Ontario K1A 0C6

OBJECTIVES

The major objective of the project is to develop a flexible farm scale fuel alcohol production system where a number of alternative process flow configurations will be examined. The system will provide a model for farmers or farm cooperatives to choose the most optimum process flow configuration for their particular situation and constraints.

DESCRIPTION

1. To develop a safe, efficient, inexpensive and multi-purpose distillation column that is appropriate for farm use and with an approximate capacity of 100-200 L/h of anhydrous ethanol.
2. To determine the optimum process operations (materials handling, pretreatment, hydrolysis, sterilization, microbial inoculation, fermentation and solid/liquid separation) as related to generically different feedstocks such as grains, sugar crops (stems and tubers), and starch tubers.
3. To evaluate and demonstrate the use and value of feeding stillage byproduct to animals (i.e., ruminant and monogastric).
4. To determine effective means for increasing the "shelf life" of stillage byproduct beyond the normal two days of safe storage, if possible.
5. To determine effective and environmentally acceptable means of reducing and/or disposing of waste water or thin stillage.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 20,000			$ 20,000
1982-83	$103,500			$123,500
1983-84	$ 76,000			$199,500
1984-85	$ 44,230			$243,730

REPORTS

STATUS AND COMMENTS

83/05/02

PROJECT DATA SHEET # 351

TITLE	Fuel Ethanol Dehydration	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #	01843-1-EL09 (OSZ81-00135)	**DURATION**	1981 - 1983
		COST	$67,000
CONTRACTOR	Wellington Engineering Ltd. 29 Hickory Street Guelph, Ontario N1G 2X2	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	E. Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Building #94 Central Experimental Farm Ottawa, Ontario K1A 0C6

OBJECTIVES

To produce novel dehydration systems for farm produced alcohol.

DESCRIPTION

1. The contractor will perform laboratory experiments to evaluate the dehydration properties of a number of organic and inorganic dessicants. Emphasis is to be placed on agricultural materials (e.g. dried cracked corn). Approximately five to ten inorganic dessicants will be examined depending on time available and conclusions drawn from a literature review. Specific energy to regenerate the dessicants and design parameters will be determined. Laboratory analysis will also include optimum corn dryness required and the suitability of cracked corn with absorbed water as a fermentation substrate.

2. The contractor will design one or more systems based on analysis of laboratory work and as described in the proposal.

3. The chosen system or systems will be constructed, installed and tested at a farm fuel alcohol plant. It is anticipated that the system will be designed for a rated capacity of 20-25L/h.

4. The system as demonstrated will be analysed in terms of cost and energy requirements. In addition, the contractor will perform a projected cost analysis for larger systems including 500,000 L/a (e.g. 150-200 L/h) and 5,000,000 L/a (e.g. 700-800 L/h).

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 5,000			$ 5,000
1982-83	$ 62,000			$ 67,000

REPORTS

STATUS AND COMMENTS

83/05/02

PROJECT DATA SHEET # 352

TITLE	Development of a System of Automatically Denaturing Ethanol Destined for Fuel Purposes	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #	01843-1-EL03/1 (0SZ82-00024)	**DURATION**	1982 - 1984
CONTRACTOR	Manitoba Research Council Canadian Food Products Development Centre 810 Phillips Street Portage la Prairie, Manitoba R1N 3J9	**COST**	$66,353
		SPONSOR	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	J. Hilliard Tel.: (204) 857-7861	**SCIENTIFIC AUTHORITY**	E. Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Building #94 Central Experimental Farm Ottawa, Ontario K1A 0C6

OBJECTIVES

A method or system that automatically denatures ethanol destined for fuel purposes is sought.

DESCRIPTION

The method or system must be tamper-proof and/or be an inherent component of the production system. The denaturing system must not be able to be bypassed. It is preferred that the ethanol/water separation system cannot operate unless the denaturing system is functioning. The ethanol must be denatured before it reaches the receiver.

A method or methods applicable to various separation systems such as distillation, membrane separation, solvent extraction, freeze concentration, molecular seive, etc. should be considered.

It is intended to develop a method or system that will render the alcohol exempt from the requirements needed for beverage alcohol. The contractor must therefore work closely with the various regultory and legislative entities that control the production of alcohol in order to meet this requirement.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 46,000			$ 46,000
1983-84	$ 20,353			$ 66,353

REPORTS

STATUS AND COMMENTS

83/05/02

PROJECT DATA SHEET # 354

TITLE	Ethanol from Cellulosics Pilot Plant	**PROGRAM IDENTIFICATION**	4.3.6.2 Biomass Conversion Tech./ Fermentation to Alcohol
CONTRACT #		**DURATION**	1982 - 1988
CONTRACTOR	Canertech Inc. 1003 - 213 Notre Dame Winnipeg, Manitoba R3B 1N3	**COST**	$200,000 to date
		SPONSOR	Energy, Mines & Resources
PRINCIPAL INVESTIGATOR	H.E. Duckworth Tel.: (204) 949-1160	**SCIENTIFIC AUTHORITY**	A. Dolenko Biomass Policy Section Energy, Mines & Resources 460 O'Connor Street Ottawa, Ontario Tel.: (613) 995-9447

OBJECTIVES

To formulate a strategy for the implementation of a program on the development and demonstration of ethanol from cellulosics at the pilot plant scale.

DESCRIPTION

Phase I Implementation study

Phase II Construction of pilot plant

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83 1983-84	$200,000 $365,000 (projected)			$200,000 $565,000

REPORTS

Implementation Study for Ethanol from Cellulose Program. March 1982

STATUS AND COMMENTS

Phase I completed. Phase II will start after Treasury Board approval. A.D.

83/05/02

PROJECT DATA SHEET # 151

TITLE	A Kinetic and Catalytic Study for the Optimization of the Fluidized Bed Gasification Process	**PROGRAM IDENTIFICATION**	4.3.6.3 Biomass Conversion Tech./ Low Joule Gasification
		DURATION	
CONTRACT #	KL229-0-4122 (OSS80-69) C103	**COST**	$169,479
CONTRACTOR	Forintek Canada Corporation 800 Montreal Road Ottawa, Ont. K1G 3Z5	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.P. Overend National Research Council Division of Energy R&D Building M-55, Suite 381 Ottawa, Ontario K1A 0R6
PRINCIPAL INVESTIGATOR	H. Tarki		Tel.: (613) 993-1342

OBJECTIVE

The goals of the kinetic study are to determine the rate (speed) of the chemical process, to identify the factors upon which the rate depends and to arrive at a reaction mechanism. These goals will be accomplished by means of a combined thermogravimetric/differential thermal (TGA/DTA) analyzer which gives the weight loss of a sample with respect to time. The heating rate and temperature range are variable. The resulting data are used in a standard "differential" method to determine the reaction mechanism. Rates can be measured directly from the TGA/DTA apparatus.

DESCRIPTION

Two types of thermogravimetric analysis will be employed.

a) Dynamic TGA - the weight of a sample will be recorded over a temperature range from 25°C to 1000°C. The heating rate will be set in the range of 2 to 15°C per minute for a variety of runs (i.e. a fixed heating rate, variable temperature).

b) Static TGA - five temperatures will be chosen in the range of 100°C to 1000°C and weight loss recorded as a function of time (fixed temperature). Selection of a given temperature will be based on the dynamic TGA results where rapid weight losses were observed. 500 mg wood samples will be used during the TGA/DTA experiments, and the reacting environment will be steam, nitrogen or air.

The goal of a catalytic study is to identify those catalysts which best enhance a given process in terms of rate, yield and quality of the product. Seven individual catalysts have been selected (based on the literature and past experience), and will be used in conjunction with the TGA apparatus and the small fluidized-bed research gasifier (100,000 BTU/hr). In addition to the use of the singular catalysts (primarily alkali carbonates and transition metals), several combinations (catalyst mixtures) will be employed. The catalysts would be introduced by impregnation and physical addition techniques.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$66,651			$ 66,651
1981-82	$98,672			$165,323
1982-83	$ 4,156			$169,479

REPORTS

None as of March 31st 1983.

STATUS AND COMMENTS

Due to engineering difficulties this work has been considerably delayed. Planned completion is now summer 1983. R.P.O. 83/04/26

PROJECT DATA SHEET # 173

TITLE	Development of Analytical Methodology for Biomass Gasification Products	**PROGRAM IDENTIFICATION**	4.3.6.3 Biomass Conversion Technology/Low Joule Value Gasification.
CONTRACT #	KL229-1-4114 (OSS81-00051) C-172	**DURATION**	April 1981 - July 1983
		COST	$236,579
CONTRACTOR	Techwest Enterprises Ltd., 3650 Wesbrook Crescent Vancouver, B.C. V6S 2L2	**SPONSOR**	Environment Canada
PRINCIPAL INVESTIGATOR	G. Esplin	**SCIENTIFIC AUTHORITY**	D.P.C. Fung CANMET Energy, Mines & Resources 555 Booth Street Ottawa, Ontario. K1A 0G1 Tel.: (613) 995-6401

OBJECTIVE

To develop a standard procedure for the collection, separation and analysis of "Dirty gas" from biomass gasification so that results from various contractors can be compared meaningfully.

DESCRIPTION The following are to be determined:

1. Volume rate of the "dirty gas" which is hot (200-400°C) and contains non-condensable gases, tarry liquid and solid particles;

2. Mass of gas, liquid and solid;

3. Quantity of the liquid fraction with special emphasis on the chemical constituents (qualitative analysis) and energy of the tarry materials;

4. Chemical composition and energy content of the gas, liquid and solid.

The principal investigator will visit concerned contractors on a fact-finding mission before the development work. The developed methodology should be simple and versatile for both pilot plant scale (gasification at a rate of 80 kg of biomass per hour) and laboratory scale (1 kg of biomass per hour). Preferably only conventional instruments such as gas chromatography, GC-MS spectrometry and gel permeation chromatography should be applied in this methodology.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$110,280			$110,280
1982-83	$126,299			$236,579

REPORTS

A workbook for Biomass Gasifier Sampling and Analysis will be available in May 1983.

STATUS AND COMMENTS

This contract work will be completed in July 1983. D.P.C.F.

83/04/26

PROJECT DATA SHEET # 307

TITLE Development, Operation and Evaluation of a Small Scale Gasification/Water Heating System

CONTRACT # 01843-1-ER13 (OSZ81-00131)

CONTRACTOR Biomass Combustion Ltd.
Canning, Nova Scotia
B0P 1H0

PRINCIPAL INVESTIGATOR J. Peill

PROGRAM IDENTIFICATION 4.3.6.3
Biomass Conversion Tech./
Low Joule Gasification

DURATION February 11, 1982
to March 31, 1984

COST $50,000

SPONSOR Agriculture Canada

SCIENTIFIC AUTHORITY
D. Marshall
Engineering & Statistical Research Institute
Research Branch
Agriculture Canada
Ottawa, Ontario
K1A 0C6

Tel.: (613) 995-9671

OBJECTIVE

DESCRIPTION

The contractor shall develop, operate and evaluate a packaged straw combustion system using conventional bales in a burner consisting of a combustion gasification chamber combined with a gas/water heat exchanger in one shell. The overall performance will be evaluated by the contractor. Combustion efficiency tests, hourly maximum outputs and emission tests shall be performed by a suitable consultant.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$13,651			$13,651
1982-83	$30,349			$44,000
1983-84	$ 6,000			$50,000

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 323

TITLE	Data Collection for Downdraft Wood Gasifier Operation	**PROGRAM IDENTIFICATION**	4.3.6.3 Biomass Conversion Tech./ Low Joule Gasification
CONTRACT #	KN107-2-4272 (OSS82-00057) C-197a	**DURATION**	July 15, '82 - December 21, '82
		COST	$91,320
CONTRACTOR	Saskatchewan Power Corporation 2025 Victoria Avenue Regina, Saskatchewan S4P 0S1	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.P. Overend National Research Council Building M-55, Room 381 Ottawa, Ontario K1A 0R6 Tel.: (613) 993-1342
PRINCIPAL INVESTIGATOR		**TECHNICAL LIAISON OFFICER**	James C.C. Hsu Dept. of Chemical Eng. Queen's University Kingston, Ontario K7L 3N6

OBJECTIVES

1. the development of empirical models for the effects of selected operating variables on down draft wood gasifier operation;
2. the evaluation of the predictive accuracy of our simulation model for down draft wood gasifiers which is currently being developed under ENFOR contrct C-197. The experimental program is designed to provide information about the effects of selected variables on gasifier operation and on the production rate and quality of fuel gas produced.

DESCRIPTION

Five operating variables have been selected for examination: i) solid feed particle size; ii) solid feed moisture content; iii) air feed rate; iv) inlet air temperature; v) ash removal rate.

Additional information which is required inlcudes regular monitoring of: i) solid feed rate; ii) solid feed temperature; iii) height of the bed; iv) fuel gas composition; v) fuel gas temperature and production rate; vi) HHV of fuel gas; vii) pressure at the top of the bed; viii) temperature and gas sampling along the length of the bed where possible.

The following data are also required: i) solid density and bulk density of wood and ash; ii) proximate and ultimate analyses of wood and ash; iii) HHV of wood and ash; iv) location of the tuyeres.

Direct measurement of fuel gas flowrate is considered essential in evaluating the overall mass balance. The data received from the sub-contractor is expected to satisfy a carbon balance of 10%. Preliminary mass and energy blances are to be included by the sub-contractor with the raw data from each run. All data collection is to occur at steady-state operating conditions although monitoring of the transients preceding steady-state would provide information about the dynamic operating behaviour of this process which could form a basis for future investigation.

Analysis of the Data The sub-contractor will provide preliminary mass and energy balances with its report of the raw data. Further analysis of these data will be performed under our current contract (ENFOR C-197) as follows: i) development of empirical models which relate the selected operating variables to gasifier performance; ii) use of the data in evaluating the predictive accuracy of our simulation model for down draft wood gasifier operation which we are presently developing under ENFOR contract C-197.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$91,320			$91,320

REPORTS

STATUS AND COMMENTS

Contract completed and data set transferred to Queen's University. R.P.O. 83/04/29

PROJECT DATA SHEET # 188

TITLE	Development and Demonstration of a Pressurized Oxygen Fluidized Bed for Wood Gasification	**PROGRAM IDENTIFICATION**	4.3.6.4 Biomass Conversion Tech./ Medium Joule Gasification
CONTRACT #	not yet determined	**DURATION**	30 months
CONTRACTOR	Biosyn Inc.	**COST**	$21,660,000 estimated
		SPONSOR	Energy, Mines & Resources (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	J. Gravelle Project Manager	**SCIENTIFIC AUTHORITY**	Allan Dolenko Energy, Mines & Resources 460 O'Connor Street Ottawa, Ontairo K1A 0E4 (613) 995-9447 ext. 300

OBJECTIVE

To design, construct and develop a fluidized bed with a capacity of 5-10 tonnes of oven-dry wood/hour using oxygen as the combustive gas and operating over a pressure range of 1 to 20 atm for the production of synthesis gas from biomass.

DESCRIPTION

This program is intended to demonstrate at a pre-commercial, pilot scale a pressurized oxygen fluidized-bed gasifier for producing synthetic gas which can be used in the manufacture of methanol.

Expected outputs: An assessment of the technology and its economic feasibility for incorporation into a methanol production plant. Results obtained will permit extrapolation of the data for the design, construction and operation of large-scale gasification plants.

FUNDING

FISCAL YEAR	SPONSOR X $1,000	CONTRACTOR X $1,000		CUMULATIVE TOTAL X $1,000
Year 1	325.0			325.0
Year 2	1,625.0	9,800.0 (capital)		11,750.0
Year 3	3,880.0	6,030.0 (capital)		21,660.0

REPORTS

STATUS AND COMMENTS

Contract yet to be signed. Currently, has stated only its intention to contract with the consortium.

83/04/26

PROJECT DATA SHEET # 257

TITLE	Molten Salt Technology for Wood to Syngas Conversion	**PROGRAM IDENTIFICATION**	4.3.6.4 Biomass Conversion Tech./ Medium Joule Gasification
CONTRACT #	31155-1-2687 (OSX82-00012) 31155-1-2687 (OSX82-00226)	**DURATION**	May 1982 to January 1984
		COST	$211,183
CONTRACTOR	SNC Inc. 1 Complexe Desjardins Case Postale 10 Succursale Desjardins Montréal, Québec H5B 1C8	**SPONSOR**	National Research Council
		SCIENTIFIC AUTHORITY	R.P. Overend National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342
PRINCIPAL INVESTIGATOR			

OBJECTIVE

To evaluate a process involving the use of molten salt technology in the conversion of wood to synthetic gas.

The work is to re-design a bench-scale molten salt bath gasification unit by incorporating or modifying those characteristics of the design which are necessary to allow the use of wood of appropriate particle size as the organic feedstock and operation in the combustion or gasification mode.

DESCRIPTION

Phase I

Estimates of the cost and proposed performance specifications are being prepared. Support of the feasibility of carrying out such studies will form part of the report.

Phase II Task I

Fourteen individual gasification tests will be carried out on samples of wood provided by NRC. During the tests the off-gas will be analyzed continuously for carbon monoxide, carbon dioxide, and hydrogen; and periodically for methane, nitrogen and water. During each test a sample of particulates in the gas will be analyzed for tar and sodium content, and a sample of the molten salt will be analysed for combustible carbon and selected melt components. Corrosion rate data will be obtained using an alloy believed to be suitable for construction of molten salt wood gasification vessels. Engineering analyses will be performed to establish test conditions, correlate test results, predict the effects fo higher pressure operation and provide input to plant design studies.

Task II

- Conceptual designs of process schemes such as the low pressure electric heating mode and the low pressure electrolytic oxygen mode.
- Costing of the conceptual process schemes to $/GH for 95% hydrogen, methanol plant feed and fuel/reducing gas.
- Technology assessment (preliminary cost-benefit, manufacture of other products, use of other wood-based feedstocks, problems in scaling ups, patent situation and requirements for further research and development).

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 19,819			$ 19,819
1983-84	$191,364			$211,183

REPORTS

STATUS AND COMMENTS

Continuation of work in conjunction with Rockwell International is planned for early 1983. R.P.O. 83/04/27

PROJECT DATA SHEET # 330

TITLE	Development of a Simple Dual-Bed Fluidized Gasifier for Biomass & other Pyrolyzable Wastes	**PROGRAM IDENTIFICATION**	4.3.6.4 Biomass Conversion Tech./ Medium Joule Gasification
		DURATION	3 years
CONTRACT #	Strategic Grant	**COST**	$63,400
CONTRACTOR	University of Western Ontario London, Ontario N6A 5B8	**SPONSOR**	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	Jan M. Beeckmans Dept. of Chemical Eng.	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

The objective of the project is the development of a simple dual-chamber fluidized bed system for gasifying biomass or garbage to produce a gas having a calorific value in the range of 10-20 MJ/N - m^3. In a dual-bed gasifier hot sand is circulated between an air-fluidized regenerator, in which char is burnt and the sand is heated to approximately 900°C, and a steam-fluidized gasifier, in which the organic material is pyrolyzed and gasified. Since the gases from the two beds do not mix, the gasifier gas is essentially nitrogen free, and it contains relatively little carbon dioxide. On the other hand, the waste gases from the combustor are composed primarily of nitrogen, carbon dioxide and water vapour. They are, in fact, similar to conventional combustion gases; however, char is such a clean fuel that it produces fewer gaseous and particulate pollutants than from combustion of the biomass in a conventional boiler.

The main advantage of dual-bed gasification is that it produces a gas in the medium calorific value range, without the necessity for using pure oxygen.

DESCRIPTION

It is proposed here to investigate the possibility of using a single, internally partitioned bed of cylindrical geometry.

The motive power for circulation of solids in this system is provided by the difference in bulk density between solids in the combustion section, which are fluidized at relatively high velocity, and solids in the gasification section, where the fluidizing velocity would be much smaller.

In Phase I, solids circulation patterns and gas mixing will be studied in a "cold" model, and a suitable design will be developed. In phase 2, a small prototype gasifier will be constructed and operated using sawdust, wood chips and other biomass.

Solids circulation will be studied by adding separable tracer particles to one of the fluidized beds, and noting their rate of appearance in the other bed. Gas mixing will similarly be studied by adding ammonia gas to the fluidizing air under one bed, and determining its concentration in the exhaust gas from the other bed. Variables to be studied include the fluidization velocity in both beds, the mean size of the solids, the height of the beds, and size and location of the orifices in the baffle separating the beds. The designs will be based on a scale of 2 tonnes/day of biomass (approximately 80 kg/h).

The cold model studies will not be restricted to purely empirical observations, and every effort will be made to understand and explain the results in terms of the underlying physical phenomena. These include the distribution of pressure with height on both sides of the vertical baffle and the mechanics of flow of fluidized solids across a submerged orifice under a small pressure gradient. A quantitative & qualitative understanding of these phenomena will permit eventual design of a small commercial or pilot plant gasifier on a substantially larger scale.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$24,600			$24,600
1982-83	$22,900			$47,500
1983-84	$15,900			$63,400

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 336

TITLE	Improved Alcohol Synthesis Through Periodic Operation	**PROGRAM IDENTIFICATION**	4.3.6.5 Biomass Conversion Tech./ Methanol
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	University of Waterloo Dept. of Chemical Engineering Waterloo, Ontario N2L 3G1	**COST**	$57,700
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	R. Hudgins	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

Our proposal has two primary objectives:

1. To establish whether forced cycling of syngas composition can improve the catalyst activity and selectivity to methanol.
2. To see if periodic operation can lead to a more uniform temperature distribution in the synthesis reactor then is observed in steady-state operation.

DESCRIPTION

1. The flow reactor equipment recently used in the study of ammonia synthesis will be converted to methanol synthesis. This equipment was built to withstand 100 atm pressure, but was found to operate easily without need for heroic measures against leakage up to about 35 atm.

2. Once the apparatus is assembled and tested, the activity, selectivity, and catalyst stability of a standard commercial methanol synthesis catalyst (e.g. ICI Cu_2O-CrO_3 catalyst) would be established in steady state operation. Runs would be made at 35 bars, with temperatures of 250°, 275° and 300°C using about 1 to 10 grams of powdered catalyst sample with high inert dilution to avoid temperature gradients so as to keep CO conversion to below 5%. For each catalyst, the influence of the CO/H2 feed ratio on conversion, selectivity and stability would be determined. Selectivity and activity would be studied using the gradientless Berty reactor. Stability would be examined in the fixed bed unit.

3. The available equipment was built for studies of periodic operation in conjunction with the baseline testing described in 2. Periodic operation would be carried out for the chosen catalyst at temperatures and feed composition found attractive for steady state operation. Primary variables for the periodic operation study would be switching frequency and cycle-split.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$21,900			$21,900
1983-84	$17,900			$39,800
1984-85	$17,900			$57,700

REPORTS

STATUS AND COMMENTS

Working in collaboration with P.L. Silveston, Chemical Engineering, University of Waterloo. R.H. 83/03/21

PROJECT DATA SHEET # 30

TITLE	Demonstration & Testing of a "Lamb" Wet-Cell Wood Burner using Hogged Wood Waste for firing a Pulp Mill Lime Kiln	**PROGRAM IDENTIFICATION**	4.3.6.6 Biomass conversion technology/Direct Combustion.
CONTRACT #	08SB.KL016-8-0125 (0SB78-00341) SP8, C14	**DURATION**	February 1979 - June 1982
		COST	$2,070,000
		SPONSOR	Environment Canada
CONTRACTOR	Lamb-Cargate Industries Ltd. P.O. Box 440, 1135 Queens Ave. New Westiminster, B.C. V3L 4Y7	**SCIENTIFIC AUTHORITY**	R.J. Neale, C.F.S. Vincent Massey Building Hull, Quebec. K1A 0E7 (613) 997-1682
PRINCIPAL INVESTIGATOR	Ian Rowe	**TECHNICAL LIAISON OFFICER**	Dr. J.F.G. MacKay Forintek Canada Corporation Western Laboratory 6620 N.W. Marine Drive Vancouver, B.C. V6T 1X2 (604) 224-3221

OBJECTIVE

To demonstrate energy conservation to the pulp and paper industry by displacing petroleum derived energy with green wood wastes.

DESCRIPTION

An innovative technique for using wood waste, developed by Lamb-Cargate Ltd. will be employed at the MacMillan-Bloedel pulp mill at Port Alberni.

Oil is currently used to heat the No. 1 lime kiln. Aim of the project is to show the feasibility of using a wet cell/ - one permitting the use of rough wet waste of all types. Oil and natural gas have been the preferred fuels in the past for technical reasons. Throughout the industry, lime kilns require large quantities of oil or natural gas. Computer simulation indicates the potential for at least 60 per cent substitution of the oil used in the lime kiln by waste wood converted to hot gases in the wet cell burner.

Lamb-Cargate has designed, constructed and installed the 60 million BTU/hour wet cell. MacMillan Bloedel will provide fuel testing, operating and maintenance facilities and scientifc assessment of the burner performance.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	I.T. & C.	CUMULATIVE TOTAL
1978-79	$400,000	$300,000	$200,000	$ 900,000
1979-80	$300,000	$300,000	$200,000	$1,700,000
1981-82	$250,000			$1,950,000
1982-83			$120,000 (NRC)	$2,070,000

REPORTS

Lamb-Cargate Ind. Ltd., Testing, Modification & Evaluation of a Lamb Wet-Cell Burner/Lime Liln. April 7, 1982, ENFOR C-14, Intermediate Technical Report

Lamb-Cargate Ind. Ltd., Oil Replacement on a Pulp Mill Lime Kiln Using Hog Fuel in a Lamb Wet-Cell Burner. New Westminster, B.C., March 1983.

STATUS AND COMMENTS

Project complete.

83/04/25

PROJECT DATA SHEET # 157

TITLE	Advanced Feedstock Preparation System for Large-Scale Hog Fuel Boilers	**PROGRAM IDENTIFICATION**	4.3.6.6 Biomass Conversion Tech./ Direct Combustion
CONTRACT #	KL229-0-4170 (OSS80-36) C149	**DURATION**	April 1980 - August 1982
		COST	$128,314
CONTRACTOR	Inproheat 680 Raymur Avenue Vancouver, B.C. V6A 2R1	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.J. Neale Place Vincent Massey Hull, Que. K1A 0E7 (613) 997-1682
PRINCIPAL INVESTIGATOR	Greg Hall	**TECHNICAL LIAISON OFFICER**	Dr. T.F.G. Mackay Forintek Canada Corporation Western Laboratory 6620 NW Marine Drive Vancouver, B.C. V6T 1X2

OBJECTIVE

1. To measure combustion parameters (temperature, gas composition and particulate loading) for a range of operating conditions at the interface between solid fuel combustion and gas phase combustion above the grate of a relatively large scale hog fuel boiler.
2. To quantitatively relate fuel characteristics (moisture content and size distribution) to boiler performance (unit steaming capacity, control response, efficiency and stack emissions).
3. To evaluate feasibility of a secondary flash dryer for reducing moisture content of the fines fraction of the product from a rotary dryer and to optimize design parameters, including inlet and outlet temperatures, velocity, length and configuration.
4. To specify criteria for improved hog fuel boiler performance.

DESCRIPTION

1. Design and fabricate a special probe and modify existing sampling train equipment, as required, to collect and analyze high temperature samples from the solid phase/gas interface zone.
2. Measure interface parameters - temperature, gas composition (O_2, CO_2, H_2O, CO, C_xH_y), and particulate loading at selected boiler operating conditions for a range of fuel characteristics.
3. Design, fabricate and construct a pilot scale secondary flash dryer.
4. Start-up and optimize operation of the pilot scale flash drying system.
5. Obtain representative samples of fuel fractions from the rotary dryer and from the suspension dryer and evaluate the feasibility of using proven process equipment for operations which could form elements of advanced fuel preparation systems.
6. Conduct controlled tests relating boiler operating parameters (unit steaming capacity, control response, efficiency, and stack emissions) to fuel characteristics (moisture content and size classification) for grate firing.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$32,648			$ 32,648
1981-82	$60,684			$ 93,332
1982-83	$34,982			$128,314

REPORTS

IMPROHEAT Industries Limited, Advanced Feedstock Preparation System for Large-Scale Hog Fuel Boilers. Vancouver, B.C., November 1982, ENFOR Project C-149. (Final Report)

STATUS AND COMMENTS

Project Complete.

83/04/26

PROJECT DATA SHEET # 186A

TITLE Coordination of the test program on boilers burning wood refuse

CONTRACT #S KL229-1-4124-B C-235
KL229-1-4124-3

CONTRACTOR Canadian Boiler Society
1 Yonge St., Suite 1400
Toronto, Ontario.
M5E 1J9

PRINCIPAL INVESTIGATOR W. Newby

PROGRAM IDENTIFICATION 4.3.6.6
Biomass Conversion Technology/Direct Combustion.

DURATION August 5, 1981
to March 31, 1984

COST $130,000

SPONSOR Environment Canada

SCIENTIFIC AUTHORITY G.K. Lee
Canadian Combustion Research Laboratory
Energy Research Laboratories
Bells Corners Complex
c/o 555 Booth Street
Ottawa, Ontario. K1A 0G1
(613) 996-4570 ext. 186

OBJECTIVE
To identify boiler installations which reflect post 1976 combustion and control technology, and to perform detailed efficiency and emissions tests on selected units.

DESCRIPTION
Task 1 The contractor shall perform whatever work may be required to assist in the planning of the total program.

Task 2 (A) Together with representatives of governments, K.V.B. Inc., Babcock and Wilcox Canada Limited, and Combustion Engineering Super Heater Limited, the contractor shall make a visit to Newcastle, N.B.,to assess the capability of steam generators operated by Boise Cascade to fire wood refuse. The boilers should preferably be rated at 45,360 kg/h of steam or more.

(B) To determine

(i) current technology features

(ii) which units are most appropriate for measuring ASME indirect boiler efficiencies and EPA emissions characteristics

(C) To identify one boiler for detailed field evaluations.

Task 3 Detailed test plans specifying firing conditions, loads and fuels, emissions measurements, sampling points, and combustion data.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$33,000			$ 33,000
1982-83	$97,000			$130,000
1983-84	$80,000			$210,000

REPORTS
Interim reports will be made available only at conclusion of all testing.

STATUS AND COMMENTS
Work on-going into 1983. Field tests have been completed in Newcastle, N.B., Harmac, B.C., and Port Alfred. See data sheet #186B for description of testing work by Envirocon Eastern Limited.

83/05/02

PROJECT DATA SHEET # 1868

TITLE	Test Program on Boilers Burning Wood Refuse	**PROGRAM IDENTIFICATION**	4.3.6.6 Biomass Conversion Technology/Direct Combustion.
CONTRACT #	KL229-1-4124-1 (OSS82-0002) C-235	**DURATION**	February 1982 - 1984
CONTRACTOR	Envirocon Eastern Ltd. 1705 Argentia Road Mississauga, Ontario L5N 3A9	**COST**	$1,013,226
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	W.H. Howell	**SCIENTIFIC AUTHORITY**	G.K. Lee Canadian Combustion Research Laboratory Energy Research Laboratories Bells Corners Complex c/o 555 Booth Street Ottawa, Ontario. K1A 0G1 (613) 996-4570 ext. 186

OBJECTIVE

To investigate the efficiency and emission characteristics of a number of modern installations in commercial use. The program will identify where improvements can be made and will provide manufacturers of equipment with valuable data which is not presently available.

DESCRIPTION

The field tests will be performed using environmental assessment sampling and analysis procedures as documented in "IERL-RTP Procedures Manual: Level 1 Environmental Assessment (Second Edition)", EPA-600/7-78-201. Bioassay analyses shall follow the procedures outlined in "IERL-RTP Procedures Manual: Level 1 Environmental Assessment Biological Tests for Pilot Studies", EPA-600/7-77-043.

Test sites:
1. Newcastle, N.B. (testing complete)
2. Harmac, B.C. (testing complete)
3. Port Alfred, Québec (testing complete)

Two other sites are being considered for testing in 1983-84.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	NRC	CUMULATIVE TOTAL
1982-83	$163,226		$150,000	$ 313,226
1983-84	$700,000			$1,013,226

REPORTS

STATUS AND COMMENTS

Continuing in 1983-84 as C-358.

83/05/02

PROJECT DATA SHEET # 212

TITLE	Effect of Particle Size on the Gross Heat of Combustion of Wood	**PROGRAM IDENTIFICATION**	4.3.6.6 Biomass Conversion Tech./ Direct Combustion
CONTRACT #	KN107-1-4318 (0SS81-00110) C-257	**DURATION**	August 1981 - September 1982
CONTRACTOR	Forintek Canada Corporation Eastern Laboratory 800 Montreal Road Ottawa, Ontario K1G 3Z5	**COST**	$56,064
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	J.M. Kryla	**SCIENTIFIC AUTHORITY**	R.P. Overend National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342

OBJECTIVE

Phase 1 To determine the relationship between particle size and calorific values of wood & bark.

Phase 2 To determine and quantify the factors responsible for the variation in calorific values with particle size.

DESCRIPTION

1. a) Homogeneous mixtures of dry hybrid poplar and eastern white spruce will be ground in a hammer-mill and/or a laboratory Wiley Mill. The material will then be separated on the basis of size.
   b) Oxygen bomb calorimetry will be utilized to determine calorific values and an evaluation on CO and water will be conducted. The gases will be analysed by gas chromatography.
   c) The effect of moisture content during comminution will also be studied.

2. a) The investigators will quantify the factors involved in particle size effect on calorific values.
   b) The content of lignin and/or hemicellulose will be determined.
   c) An elemental analysis will be done on C, H, and O and approximate elemental analysis of fixed carbon and volatile content will be done.
   d) The ash content will also be determined.
   e) Differential scanning calorimetry(DSC) will be done on selected materials of 2 mesh size.
   f) Enthalpy changes and transition temperatures will be measured for more complete analysis. DSC will be used to verify the premise that less energy is required to ignite thermal degradation in smaller particles.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$31,564			$31,564
1982-83	$24,500			$56,064

REPORTS

KRYLA J.M., Forintek Canada Corporation, Effect of Particle Size on Gross Heat of Combustion of Wood. Ottawa, Ontario, March 1983. ENFOR Project C-257.

STATUS AND COMMENTS

Project Complete.

83/04/26

PROJECT DATA SHEET # 242

TITLE	Evaluate Canola Oil as a Fuel for Farm Diesel Engines	**PROGRAM IDENTIFICATION**	4.3.6.6 Biomass Conversion Tech./ Direct Combustion
CONTRACT #	01843-1-EL05	**DURATION**	December 1981 to March 31, 1983
CONTRACTOR	Department of Agricultural Engineering University of Saskatchewan Saskatoon, Saskatchewan	**COST**	$109,230
		SPONSOR	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	R.C. Strayer Tel.: (306) 343-3191	**SCIENTIFIC AUTHORITY**	F.B. Dyck Agriculture Canada Research Branch Research Station Swift Current, Saskatchewan S9H 3X2 Tele.: (306) 773-4621

OBJECTIVE

To undertake a comprehensive evaluation of the suitability of canola oils for farm diesel engines including engine wear, exhaust emission, engine performance and the development of oil extraction techniques from canola seeds.

DESCRIPTION

The task is to be divided among three participants.

1. The University of Saskatchewan is to conduct long term engine tests using a two cylinder Petter. The Petter will use a split diesel-canola fuel, (low erucic expeller oil, high erucic expeller oil, methyl ester). The study will examine power output, fuel consumption, viscosity and the rate of contaminant build up in the oil. The University will manage all aspects of the contract.

2. The Saskatchewan Research Council will conduct analyses of exhaust emissions of the following fuels: diesel, canola oil, 50/50 blend of canola and diesel, methyl esters of canola, 9:1 canola - ethanol blend, and high erucic type rapeseed oil. The lubrication oil will be examined after use.

3. The POS Pilot Plant Corp. will monitor the quality of oils used in engine tests and continue the evaluation of a farm-size mini-press for producing oil. POS is to also conduct a pilot plant production analysis of several esters of canola oil, including economics of production and uses of all by-products.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$25,000			$ 25,000
1982-83	$84,230			$109,230

REPORTS

Final report will be in by March 31, 1983.

STATUS AND COMMENTS

Refer to project data sheet 172 for previous work. 83/04/26

PROJECT DATA SHEET # 274

TITLE	Conversion of Oil/Gas Heating Plant to Biomass Fueled Plant	**PROGRAM IDENTIFICATION**	4.3.6.6 Biomass Conversion Tech./ Direct Combustion
CONTRACT #	KH405-1-0194 (OSS81-00202) P-228	**DURATION**	1981-1983
		COST	$34,902
CONTRACTOR	Charles Turner & Associates Limited Don Mills Road Don Mills, Ontario	**SPONSOR**	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	Lorne Riley Great Lakes Forest Research Centre Environment Canada P.O. Box 490 1219 Queen Street E. Sault Ste. Marie, Ontario P6A 5M7

OBJECTIVE

To undertake a study to determine the feasibility of converting oil/gas-fired energy plants at CFB Borden to wood-fired energy production. To undertake the study one medium-sized energy plant will be selected by CFB Borden as a representative model and all investigations will focus on the feasibility of converting this plant to wood-produced energy. Inferences will be made, based on this investigation, for the potential for conversion of the other energy plants on the Base.

DESCRIPTION

1. The Contractor shall inspect the energy plant selected and the Contractor shall determine the most suitable wood-fueled energy plant(s).
2. The Contractor shall determine the types and forms of fuels required.
3. The Contractor shall conduct a survey of the potential long-term forest biomass supply within an economic transport distance from CFB Borden and shall determine the long-term supply of forest biomass acutally available and obtainable for use in the proposed plant.
4. The Contractor shall make a survey of lands vacant or abandoned within a 25-mile radius of CFB Borden which are suitable for the growing of hybrid poplar energy plantations.
5. The Contractor shall determine:
   a) the cost of converting the existing plant to the proposed system
   b) the delivered price per green tonne by product type in 1981 dollars and the anticipated incremental costs for delivered wood through the year 2000
   c) the cost of operating and maintaining the proposed plant over a 20-year write-off period
   d) the cost per thousand B.T.U.'s produced in the proposed plant by biomass fuel type with comparative data for gas/oil in the existing plant.
6. The Contractor shall provide comment on the feasibility of converting additional plants at CFB Borden.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$29,433			$29,531
1982-83	$ 5,469			$34,902

REPORTS

Charles G. TURNER & Associates Ltd., Feasibility Study on the Conversion of an Oil/Gas Heating Plant at C.F.B. Borden to a Biomass Fuel Plant. Don Mills, Ontario, September 1982.

STATUS AND COMMENTS

Final Report Available.

83/04/27

PROJECT DATA SHEET # 306

TITLE	Study of the Catalytic Esterification of Canola Oil for Farm Diesel Engines	**PROGRAM IDENTIFICATION**	4.3.6.6 Biomass Conversion Tech./ Combustion
CONTRACT #	01843-1-EL12 (OSU81-00459)	**DURATION**	January 9, 1982 to June 1984
		COST	$65,000
CONTRACTOR	University of Guelph Guelph, Ontario N1G 2W1	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATORS	Martin Nye Dept. of Chemistry H. Southwell School of Engineering	**SCIENTIFIC AUTHORITY**	Emanuel Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671

OBJECTIVE

To develop an inexpensive and energy efficient process for the esterification of rapeseed oil and to test the product as an alternative fuel for diesel engines.

DESCRIPTION

The experimental conditions for the esterification process will be systematically studied in the Department of Chemistry laboratories. Each fuel produced will be tested in the heat engines laboratory of the School of Engineering. In selecting the most promising process/fuel, the main criteria employed will be:

1) Viscosity of fuel
2) Contamination of exhaust gas
3) Cetane number of fuel
4) Solidification properties at low temperature
5) Projected capital cost of equipment for production, preliminary study pilot plant design
6) Projected operating cost for production
7) Suitability of process for on-farm or cooperative installation
8) Energy required for production
9) Safety of production process

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$11,000			$11,000
1982-83	$48,000			$59,000
1983-84	$ 6,000			$65,000

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 97

TITLE	Liquid Fuels & Chemicals from Aspen.	**PROGRAM IDENTIFICATION**	4.3.6.8 Biomass Conversion Technology/Oil Production.
CONTRACT #	05SS.KL229-9-7112 (0SS79-00057) C48	**DURATION**	4 years
CONTRACTOR	Dept. Chemistry & Chemical Engineering University of Saskatchewan Saskatoon, Saskatchewan	**COST**	$238,079
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	Dr. R.L. Eager 343-2954 Dr. J.F. Matthews 343-3080 Dr. J.M. Pepper 343-2950 area code (306)	**SCIENTIFIC AUTHORITY**	R.J. Neale, C.F.S. Vincent Massey Building Hull, Quebec. K1A 0E7 Tel.: (613) 997-1682
		TECHNICAL LIAISON OFFICER	J.F.G. Mackay Forintek Canada Corporation Western Forest Products Lab 6620 N.W. Marine Drive Vancouver, B.C. V6T 1X2 Tel.: (604) 224-3221

OBJECTIVE

To conduct a detailed study of the conversion of aspen wood into a portable sulfur-free fuel oil as the major fraction and a variety of oxygenated chemicals (alcohols, ketones and acids) with solvent properties. The process involves the interaction of wood with carbon monoxide in the presence of a catalyst.

DESCRIPTION

The research includes an examination, using a small-scale batch apparatus, of the major process variables: temperature, reaction time, relation of carbon monoxide to substrate, nature and amount of catalyst in an attempt to optimize the production of oil and chemicals.

First Year - Completion of initial study of process variables using batch reactor; Initial studies on use of recycled oil as reaction medium; Completion of separation and identification of major low-boiling components of water-soluble fraction.

Second Year - Completion of studies on use of recycled oil as reaction medium; Continuation of isolation and identification of higher-boiling water-soluble fractions; Design, construction and initial use of small-scale continuous flow reactor; Development of proposed mechanism of reaction and role of each of the cellulose, hemicellulose and lignin fractions of the wood.

Third Year - Operation of a small-scale, semi-continuous operation equipment to determine more reliable data on the kinetics of the process to be used to obtain an economic evaluation of an industrial-sized operation. (This phase has been extended into the fourth year.)

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1979-80	$32,407			$ 32,407
1980-81	$45,974			$ 78,381
1981-82	$68,392			$146,773
1982-83	$91,306			$238,079

REPORTS

PEPPER J.M., EAGER R.L. and MATTHEWS J.F., Study of the Conversion of Lignocellulosic (Aspen) Materials to Liquid Fuels and Chemicals. University of Saskatchewan, Saskatoon, Sask. March 1981. ENFOR Project C-48(1). (Available from ENFOR Secretariat.)

PEPPER J.M., EAGER R.L. and MATTHEWS J.F., Production of Liquid Fuels and Chemicals from Lignocellulosic (Aspen) Materials. University of Saskatchewan, Saskatoon, Sask. 1982. ENFOR Project C-48(2). Final Report

STATUS AND COMMENTS

83/05/02

PROJECT DATA SHEET # 210

TITLE	Characterization of the Pyrolytic Oils from Trembling Aspers	**PROGRAM IDENTIFICATION**	4.3.6.8 Biomass Conversion Tech./ Oil Production
		DURATION	August 1981 - June 1982
CONTRACT #	KN107-1-4315 (OSS81-00108) C-256	**COST**	$36,849
CONTRACTOR	Université de Sherbrooke 2500 University Blvd. Sherbrooke, Québec J1K 2R1	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.J. Neale Place Vincent Massey Hull, Québec K1A 0E7 (613) 997-1682
PRINCIPAL INVESTIGATOR	C. Roy Dépt. de génie chimique	**TECHNICAL LIAISON OFFICER**	R. Graham Forintek Canada Corporation Eastern Laboratory 800 Montreal Road Ottawa, Ontario

OBJECTIVE

To develop a method for characterizing biomass synthetic oils that will facilitate the use of a common and reliable analytical basis for all Canadian research on these oils.

DESCRIPTION

1. The development and application of an extraction method for the characterization of hydrogenolysis oils.
2. The development and application of another extraction method for the characterization of pyrolytic oils.
3. The development of statistically proven procedures for determining the gases issuing from extraction processes.
4. The development of a new method for characterizing pyrolysis oils, involving distillation column chromatography, gas chromatography and liquid chromatography.

A. To develop techniques for the separation of pyrolytic oils from Populus tremuloides obtained by thermal decomposition under vacuum at 530°C, by high pressure liquid chromatography and gas chromatography.
B. Identification of the major and minor components of these oils.
C. Application of these techniques for the analysis of the pyrolytic oils produced from other lignocellulosics (hard woods, soft woods, bark, etc.)
D. A quantitative analysis of the major pyroligneous constituents from Populus tremuloides.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$25,346			$25,346
1982-83	$11,503			$36,849

REPORTS

ROY C. and MÉNARD H., University of Sherbrooke, Caractérisation des huiles pyrolytiques du peuplier faux-tremble. février 1983. ENFOR Project C-256. Final Report.

STATUS AND COMMENTS

Completed.

83/04/26

PROJECT DATA SHEET # 235

TITLE	Production of Oils from Wood	**PROGRAM IDENTIFICATION**	4.3.6.8 Biomass Conversion Tech./ Oil Production
CONTRACT #	Strategic Grant		
CONTRACTOR	Génie Chimique Université de Laval Québec, Québec	**DURATION**	3 years
		COST	$206,884
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	S.C. Kaliaguine		
		SCIENTIFIC AUTHORITY	n/a

OBJECTIVE

This project includes a study of the technique for the production and the upgrading of pyrolytic oils prepared from wooc. For the production we propose to employ the technique of supercritical extraction considered to be particularly promising economically, since it avoids the costs of the production and compression of the reducing gases. For the upgrading, we propose to use the catalyst ZSM-5 which enables the production of gasoline from methanol and a number of other organic compounds containing oxygen.

DESCRIPTION

Sub-Project 1: Production of pyrolytic oils by the super-critical extraction method. The aim is to study the conditions of mass transfer and also heat transfer during pyrolysis. We are interested not only on the effect of these parameters on the conversion into liquid product, but also on their effect on the conversion into gasoline obtained in the course of the standard ZSM-5 process.

Sub-Project 2: The study of the conversion of the pyrolytic oils on ZSM-5. The object will be to determine the optimum conditions of the catalytic procedure for the production of gasoline in the absence of all additional reactants by using a pulse reactor. By using the oils produced in sub-project 1 as reactants in sub-project 2, allows the simultaneous optimization of the two procedures, the production of the oils and their upgrading.

Sub-Project 3: The study of the conditions for the synthesis of zeolite ZSM-5 and the catalysts obtained by depositing different metals in the zeolite. The properties of the catalysts thus obtained, will also be studied by examining the reaction of the major constituents such as phenol, pyrogallol, and levoglucosan with CO and the mixture of CO and H_2 under pressure. The object is to investigate the catalysts which can be used to produce the reaction in sub-project 2(mainly a dehydration) and at the same time with the reaction of gas to water in order to eliminate oxygen which enters the oil in the form of CO_2.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	EQUIPMENT	CUMULATIVE TOTAL
1981-82	$48,500		$32,779	$ 81,279
1982-83	$52,127		$30,978	$164,384
1983-84	$42,500			$206,884

REPORTS

Related publications as of 1981

VIJAYAN C.P., GHALY E., KALIAGUINE S., GALIBOIS A., Moisture Evacuation during compressed natural gas discharge. Submitted for publication.

KALIAGUINE S., GNAKOURY M., ROBERGE P.C., Propriétés photocatalytiques de Ta_2O_5/SiO_2. Accepted for publication, Can. J. Chem. Eng.

KALIAGUINE S., RAMALHO R.S., LE BACH B., Excess enthalpies of binary gaseous system C_2H_4-CO_2 Can. J. Chem. Eng. 57, 363 (1979).

STATUS AND COMMENTS

The three sub-projects are proceeding satisfactorily. A Master's thesis was defended on project 1 using methanol as a solvent. Another project is in progress using other solvents of which the most interesting is THF. S.C.K.

83/04/26

PROJECT DATA SHEET # 325

TITLE	Processes for the Conversion of Wood to Liquid Fuels & Chemicals through a Continuous/Semi-Continuous Liquefaction Unit	**PROGRAM IDENTIFICATION**	4.3.6.8 Biomass Conversion Tech./ Oil Production-Liquefaction
CONTRACT #	KN107-2-4069 (OSU81-520) C-288 C435	**DURATION**	March 22, 1982 to March 31, 1983
		COST	$38,383
CONTRACTOR	University of Toronto Dept. of Chemical Engineering Toronto, Ontario M5S 1A4	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.P. Overend National Research Council Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tel.: (613) 993-1342
PRINCIPAL INVESTIGATOR	David G.B. Boocock & Donald Mackay		

OBJECTIVES

1. To operate a laboratory scale continuous/semi-continuous unit constructed under ENFOR contract C-44 and thereby gather performance data.
2. To compare these results with those obtained from a fast heat-up batch liquefaction unit and hence determine the better process of the two.
3. To investigate the upgrading of oils produced in wood liquefaction through the operation of a bench scale cracking unit.

DESCRIPTION

An existing laboratory scale wood liquefaction unit will be operated to obtain operating data related to feed rate, product discharge rate, slurry density and catalyst loading. A rapid heat-up batch system will also be operated. Comparison of data will take place to determine the most suitable process. Studies will also take place on the upgrading of the oil products using a laboratory scale cracking unit.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$38,383			$38,383

REPORTS

ENFOR report C-44 describing work on both objectives 1 & 2 above upto the Summer 1982 is now available.

STATUS AND COMMENTS

Despite the long delay at Autoclave Inc. in modifying the slurry feed port to the autoclave, the overall program is in excellent shape with useful results being obtained. Some results have been incorporated into a revised flow sheet produced by SNC during the update on liquefaction. R.P.O. 83/04/29

PROJECT DATA SHEET # 339

TITLE	Chemical Characterization of Wood Conversion to Liquid Fuels	**PROGRAM IDENTIFICATION**	4.3.6.8 Biomass Conversion Tech./ Oil Production-Liquefaction
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	University of Toronto Toronto, Ontario M5S 1A1	**COST**	$84,000
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	T.T. Tidwell Dept. of Chemical Eng.	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

To perform comparative analyses on oil samples produced via liquefaction of biomass.

DESCRIPTION

The specific work proposed is first to do comparative analyses of wood oils prepared in different laboratories. This task was given a high priority at the Saskatoon meeting on Biomass Liquefaction. Representative samples from participating laboratories are now being gathered. We have to also set about doing a systematic survey with our apparatus of the effect of reaction variables on product properties. Work has already been done changing catalyst, hydrogen pressure, and reaction time, and further studies including change in the feedstock are planned.

We also intend to attempt model reactions in our hydrogenation apparatus to see if synthetic mixtures of chemicals give rise to the products observed. We shall also test the reactivity of compounds such as anisole under the reaction conditions to determine the conversion to products such as cyclohexane, cyclohexanol, phenol, and possible other products. This approach of ours promises to be quite rewarding for providing a basic understanding of the chemistry involved.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$28,000			$28,000
1983-84	$28,000			$56,000
1984-85	$28,000			$84,000

REPORTS

STATUS AND COMMENTS

Working in collaboration with D.G.B. Boocock, Dept. of Chemical Engineering.

83/04/29

PROJECT DATA SHEET # 71

TITLE	Supercritical Gas Extraction of Chemicals from Forest Products.	**PROGRAM IDENTIFICATION**	4.3.6.9 Biomass Conversion Technologies/Chemical Fredstocks.
CONTRACT #	KL229-9-7045 C51	**DURATION**	4 years
		COST	$239,843
CONTRACTOR	Division of Applied Chemistry B.C. Research 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.J. Neale, C.F.S. Place Vincent Massey Hull, Quebec. K1A OE7 (613) 997-1682
PRINCIPAL INVESTIGATOR	John Howard Tel.: (604) 224-4331	**TECHNICAL LIAISON OFFICER**	J.F.G. MacKay Forintek Canada Corporation Western Laboratory 6620 N.W. Marine Drive Vancouver, B.C. V6T 1X2 (604) 224-3221

OBJECTIVE

To attempt the extraction of essential oils, naval stores and lignins from forest products using gases at very high pressures at just above their critical temperatures and by such means save energy relative to the more conventional methods of extraction and also to maximize yield and minimize decomposition often associated with such methods.

DESCRIPTION

Forest product substrates will be contacted with various gases at very high pressures and at temperatures slightly above their critical points. The gases chosen for extraction will be those which are thought to show the most affinity for the desired extract. Thus polar gases are more likely to have a greater positive effect on the vapour pressure of a polar extractive than a non polar gas. The "solubilized" extractives will be recovered from the gas phase upon release of the pressure in a separate chamber. Equipment design will be based to some extent upon experience gained in the supercritical gas extraction of coal.

First a literature search will be carried out to determine whether supercritical gas extraction has received attention in the isolation of or modification of forest product chemicals. Next a laboratory investigation will be carried out on extraction of non polar essential oils from foliage via supercritical gas extraction, retaining the residues for possible consideration as animal feeds. Thirdly the relatively non polar volatile oils including turpentine, fatty and resin acids (naval stores) and steroids from fresh wood will be extracted using gases at high pressures limiting the wood species chosen for the study to those of commercial importance in western Canada. Next the polar lignin extractives occuring in wood and bark will be examined, which materials because of their relatively low volatility and frequent chemical instability, will represent the greatest challenge to supercritical gas extraction.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1979-80	$ 44,218			$ 44,218
1980-81	$ 83,480			$127,698
1981-82	$103,000			$230,698
1982-83	$ 9,145			$239,843

REPORTS

HOWARD J., Supercritical Gas Extraction of Chemicals from Forest Products. March 1980 (Interim report)

McDONALD E.C., HOWARD J., BENNETT B., Supercritical Gas Extraction of Chemicals from Forest Products. Phase II, June 1981 (Interim report)

McDONALD E.C., HOWARD J., BENNETT B., Chemicals from Forest Products by Supercritical Gas Extraction. Phase III, Final Report.

(Available from ENFOR Secretariat or Energy Library)

STATUS AND COMMENTS

Project Complete R.J.N. 83/04/18

PROJECT DATA SHEET # 140

TITLE	High Intensity Pyrolysis of Biomass	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Technology/Pyrolysis
CONTRACT #	KL229-0-4118 (OSS80-90) C-147	**DURATION**	April 1980 - March 1983
CONTRACTOR	University of Western Ontario Department of Chemical Engineering London, Ont. N6A 5B9	**COST**	$251,686
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	M.A. Bergougnou (519) 679-3326	**SCIENTIFIC AUTHORITY**	D.P.C. Fung Energy, Mines & Resources CANMET 555 Booth Street Ottawa, Ontario K1A 0G1 Tel.: (613) 995-6401

OBJECTIVE

1. Development at the bench level of a versatile process for the co-production of ethylene, reactive chemical intermediates, synthesis gas, enriched fuel gas and power by high intensity pyrolysis of biomass.
2. Design and build a new reactor for the study of kinetics and product yield structure of the above process.
3. Feasibility design of a commercial plant based on the above.
4. Design of a pilot plant and stake-out of the pilot plant program.

DESCRIPTION

High intensity pyrolysis is characterized by 1) extremely fast feed heat-up rates 2) ultra-short and uniform residence time at high temperatures 3) very rapid quench of products. The proposed reactor will meet the above criteria by 1) very fast mixing of hot heat carrier with fresh ground wood 2) passing the mixture downflow in dilute phase form in a tubular reactor for a very short and controlled time 3) quenching the reactor products with cold solids. The effect of major process variables will be studied: temperature, pressure, residence times, steam and hydrogen treat rates. Various woods and wood components, e.g. lignin, cellulose, will be used.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$ 51,380			$ 51,380
1981-82	$133,179			$184,559
1982-83	$ 67,127			$251,686

REPORTS

STATUS AND COMMENTS

A final report will be available in May 1983. The contract will be complete by March 31, 1983.

D.P.C.F. 83/04/14

PROJECT DATA SHEET # 184

TITLE	Continuous flash pyrolysis of wood	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Technology/Pyrolysis.
CONTRACT #	K1229-1-4122(0SS81-00004) C-223	**DURATION**	April 1981 - April 1983
		COST	$230,227
CONTRACTOR	University of Waterloo Dept. of Chemical Eng. Waterloo, Ontario. N2L 3G1	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.J. Neale Place Vincent Massey Hull, Quebec. K1A 0E7 (613) 997-1682
PRINCIPAL INVESTIGATOR	D.S. Scott	**TECHNICAL LIAISON OFFICER**	R.G. Graham University of Western Ontario Faculty of Eng. Science London, Ontario. N6A 5B9

OBJECTIVE

To design, construct, and test equipment for continuous flash pyrolysis of wood.

DESCRIPTION

1. Construction of a cold flow unit of glass and acrylic, testing of circulation loops in cold flow.
2. Design and construction of a 1kg/h continuous flash pyrolysis unit.
3. Determination of optimal yields and conditions, including tests with and without catalysts, using aspen poplar.
4. Further tests on one or two additional softwoods, bark twigs etc. at near optimal conditions.
5. Combustion tests, characterization of products.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 94,353			$ 94,353
1982-83	$135,874			$230,227

REPORTS

•

STATUS AND COMMENTS

83/04/14

PROJECT DATA SHEET # 264

TITLE	An Investigation of the Fast Pyrolysis of Wood and its Components using the Ultrapyrolysis Process	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Tech./ Pyrolysis
CONTRACT #	31155-2-2647 (OSU82-00285)	**DURATION**	January 1983 - December 1985
		COST	$240,471
CONTRACTOR	University of Western Ontario Room 101 Stevenson Lawson Building London, Ontario NOA 5B8	**SPONSOR**	National Research Council
		SCIENTIFIC AUTHORITY	W. Graham National Research Council Montreal Road Building M-12 Room 343 Ottawa, Ontario K1A OR6 Tele.: (613) 993-9255
PRINCIPAL INVESTIGATOR	M.A. Bergougnou Dept. of Chemical Eng.		

OBJECTIVES

1. Assess the fast pyrolysis research to date relative to Ultrapyrolysis.
2. Characterize the production of chemical intermediates as a function of various experimental variables during the fast pyrolysis of wood and its components.
3. Derivation of kinetic equations suitable for design and performance equations.
4. Prepare detailed designs for a fast pyrolysis pilot plant and a commercial prototype.

DESCRIPTION

Phase I — A literature survey consisting of 1) characterization of the concept of fast pyrolysis and its relationship to other thermochemical conversion processes, and; 2) identification of major fast pyrolysis research programs and a summary of equipment, feedstocks, experimental parameters and results will be conducted.

Phase II — The experimental program will consist of initial equipment design modifications and maintenance along with the actual research using biomass feedstocks.

Phase III — Design of pilot plant and a commercial prototype.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1983	$81,362			$ 81,362
1984	$80,680			$162,042
1985	$78,429			$240,471

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 318

TITLE	Study of Liquid Fuels from the Flash Pyrolysis of Agricultural Biomass	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Tech./ Pyrolysis
CONTRACT #	01916-2-EL18 (OSU82-00126)	**DURATION**	June 22, 1982 to June 1, 1983
		COST	$30,000
CONTRACTOR	University of Waterloo Dept. of Chemical Eng. Waterloo, Ontario N2L 3G1	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	D.S. Scott	**SCIENTIFIC AUTHORITY**	E. Manolakis Engineering & Statistical Research Institute Agriculture Canada Central Experimental Farm Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671

OBJECTIVE

DESCRIPTION

1. To determine flash pyrolysis conditions giving maximum liquid yields for two or more common cellulosic agricultural materials (wheat straw, corn stover or others).
2. To prepare sufficient quantity of liquid products in a 3 kg/h continuous unit to allow combustion tests, as well as process unit performance tests.
3. To evaluate the chemical characteristics of the liquid products and to attempt some simple chemical upgrading and evaluation such as:

   a) liquid or vapour phase hydrogenation/cracking;
   b) detoxification of carbohydrates for further hydrolysis to fermentable sugars and;
   c) improve the characteristics of the liquids as a heating fuel (e.g. viscosity reduction).

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$24,000			$24,000
1983-84	$ 6,000			$30,000

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 326

TITLE	Economic Evaluation of the Gas Yields from a Plasma Pyrolysis Gasification System using Wood-Based Fuels	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Tech./ Pyrolysis
CONTRACT #	KN107-2-4131 (0SS82-00027) C-293	**DURATION**	May 25, 1982 to February 23, 1982
		COST	$61,325
CONTRACTOR	Resorption Canada Ltd. 2465 Stevenage Drive Ottawa, Ontario K1G 3W2	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.J. Neale Canadian Forestry Service PVM Bldg., 20th Floor 351 St. Joseph Blvd. Hull, Québec K1A 1G5 Tel.: (819) 997-3409
PRINCIPAL INVESTIGATOR		**TECHNICAL LIAISON OFFICER**	Namir Sayegh Pulp & Paper Research Inst. 570 St. John's Blvd. Pointe Claire, P.Q. H9R 3J9 Tel.: (514) 697-4110

OBJECTIVE

To optimize the gas yields from a plasma pyrolysis facility for various representative wood-based fuels and study the economic viability of a commercial scale wood gasification system using plasma heat. Optimization will centre on maximization of the volume and calorific value of the output gas (for direct use as a fuel) and a maximization of the quantity of particular constituents (for use as a synthesis gas).

DESCRIPTION

Two different types of biomass fuels of varying moisture content will be pyrolysed. For each condition a measured amount of biomass will be pyrolyzed at different temperatures and steam injection rates. Also gas chromatography and residual solids analysis will be conducted to yield energy and mass balances. The pyrolysis process will be optimized to produce the optimum gas yields at the lowest operating costs for each of the five fuel materials. Production capital and operating costs will be estimated for commercial application.

The tests will include two types of fuel, namely hogged fuel at moisture contents of 12% and 62% and crushed poplar. A total of 60 runs (20 runs for each different type of fuel or moisture content) will be performed as shown below:

Fuel Type	Moisture Content	Total Runs
Hogged Fuel	62% (as received)	20
	12%	20
Crushed Poplar	(as received)	20
TOTAL RUNS		60

At the commencement of the experiment runs will be at temperatures 800, 1000, 1200 and 1400°C. Approaching optimization, run temperatures will be 1000, 1100 and 1200°C plus one temperature chosen from the results to enable us to complete the curve and pinpoint the optimum processing conditions.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$61,325			$61,325

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 328

TITLE	Detailed Design, Construction and Operation of a Vacuum Pyrolysis Process Development Unit (PDU)	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Tech./ Pyrolysis
		DURATION	April 14, '82-March 31, '84
CONTRACT #	KN107-1-4606 (OSU82-00005) C-326	**COST**	$335,470
		SPONSOR	Environment Canada
CONTRACTOR	University of Sherbrooke Sherbrooke, Québec J1K 2R1	**SCIENTIFIC AUTHORITY**	R.J. Neale Canadian Forestry Service PVM Building, 20th Floor 351 St. Joseph Blvd. Hull, Québec K1A 1G5 Tel.: (819) 997-9391
PRINCIPAL INVESTIGATOR	Christian Roy	**TECHNICAL LIAISON OFFICER**	R.G. Graham U. of Western Ontario Dept. of Chemical Eng. London, Ontario N6A 5B8

OBJECTIVES

1. To develop at the PDU level in a continuous process, the vacuum pyrolysis technology designed and checked successfully at the laboratory level.
2. To conduct the appropriate engineering studies at the technology level (e.g. handling of solids, heat transfer, cooling and recovery of organic vapors, mass transfer, etc. . .).
3. To determine the mass and energy budgets and thermal efficiency of the process.
4. To refine and characterize the pyroligneous distillate. Aside from our own samples, tars from conversion proceses studied in other Canadian laboratories will be characterized in order to compare the effectiveness of our technique.
5. To determine the economic value for the vacuum pyrolysis process.

DESCRIPTION

The proposed PDU assembly will have the following main characteristics:

1. traditional auger-type feed system - Granulometry: variable, from wood particles to pieces of the size of chips;
2. multiple-hearth furnace modified to operate at a lower pressure - the heating will be allothermic (external), either based on a eutectic salt-type heat carrier (inexpensive) or by electric heating (more costly) - the proposed maximum capacity will be 1 kg/h;
3. vapor cooling system, adjustable for each of the furnace hearths;
4. pegasus-type batch distillation column.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$138,510			$138,510
1983-84	$196,960			$335,470

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 329

TITLE	Electrical Discharge Flash Pyrolysis of Biomass	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Tech./ Pyrolysis
CONTRACT #	KN107-1-4605 (OSU82-00043) C-334	**DURATION**	May 11, '82 - March 31, '83
		COST	$47,328
CONTRACTOR	University of Western Ontario Stevenson-Lawson Building Chemical Engineering Room 101 London, Ontario N6A 5B8	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.P. Overend National Research Council Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tel.: (613) 993-1342
PRINCIPAL INVESTIGATOR	J.M. Beeckmans		

OBJECTIVES

1. A preliminary experimental investigation, on a small scale, of the products obtainable from flash pyrolysis of biomass in the presence of nitrogen, hydrogen and vacuum, using a high-voltage electrical discharge as the energy source.
2. Subject to encouraging results from the preliminary experimental study, to make an economic evaluation of a commercial plant based on this principle.
3. Subject to indications that a process may be commercially viable, to construct, test and evaluate a prototype commercial electro-flash-pyrolysis cell.

DESCRIPTION

Flash pyrolysis involves very rapid heating of biomass in the absence of air, followed by rapid quenching of the reaction products. It is proposed to achieve almost instantaneous pyrolysis by discharging a large, high voltage capacitor through the biomass contained between two electrodes. Sawdust, wood chips and whole wood will be employed as biomass.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$47,328			$47,328

REPORTS

STATUS AND COMMENTS

Work in progress. R.P.O. 83/04/29

PROJECT DATA SHEET # 331

TITLE	Ultrafast Pyrolysis (Ultrapyrolysis) of Heavy Oils and Solid Fuels	**PROGRAM IDENTIFICATION**	4.3.6.11 Biomass Conversion Tech./ Pyrolysis
		DURATION	3 years
CONTRACT #	Strategic Grant		
CONTRACTOR	University of Western Ontario Dept. of Chemical Engineering London, Ontario N6A 5B9	**COST**	$148,140
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	M.A. Bergougnou	**SCIENTIFIC AUTHORITY**	

OBJECTIVES

1. To develop a novel contactor for an ultra fast pyrolysis (ULTRAPYROLYSIS) process working on heavy oils and solid fuels to give ethylene and BTX building blocks for the manufacture of petrochemicals and synthetic transportation fuels.
2. To develop a method for pneumatically transporting finely divided solid fuel in dense phase.
3. To develop a high mass-flux, high-shear, short residence time solid-solid mixer (VORTICAL MIXER) which will be able to mix, typically within 20 milliseconds, a stream of hot heat carrier particles with a stream of solid fuel particulates.
4. To develop an efficient separation system for removing spent solids from product gas.

DESCRIPTION

The research program includes: (a) Development of methods for flowing solid fuel, thermofor and cryofor particulates in dense phase with a limited amount of transport gas. This phase could be carried out in cooperation with PNEUVEYOR LTD. of Woodstock, Ontario, a firm manufacturing pneumatic transport systems; (b) Development of high mass-flux, high-shear, short residence time solid-mixers: operating conditions and mixer configurations will be selected which will produce a high level of particulate mixing uniformity between the thermofor and the solid fuel within a very short time, typically within 20 milliseconds. A series of larger and larger cold models will be built to see how the selected VORTACTORS perform when they are scaled up to large sizes. The mixing of the two solids will be studied in a simulated reactor environment by means of the two-phase flow probes previously developed in our laboratory for the study of entrainment in the dilute phase above fluidized beds. In addition, a new technique to test the mixing of the solids coming out of the VORTACTORS will be developed. It uses a fast moving belt located at the exit of the VORTACTOR. Particules will impinge on the belt and will stick to it thanks to a special glue spread on the belt. Later on, sections of the belt will be studied by photomicroscopic means to characterize the mixing patterns of the thermofor and the solid fuel. Correlations will be worked out which will give the conditions required to achieve high levels of quasi-instantaneous mixing of two solids in commercial scale VORTACTORS; (c) Development of an efficient separation system for quickly removing the solids from the product gas upstream of the CRYOVORTACTOR.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$49,380			$ 49,380
1982-83	$49,380			$ 98,760
1983-84	$49,380			$148,140

REPORTS

STATUS AND COMMENTS

83/03/22

BIOENERGY - STRATEGIC STUDIES

Anaerobic Fermentation

Fermentation of Pentoses

Genetic Manipulation of Microbial Strains for Energy Production

Fluidizable Heat Storage

Molecular Models of Photosynthesis

Solar Energy Conversion via Photosynthetic Bacteria

Catalytic Synthesis

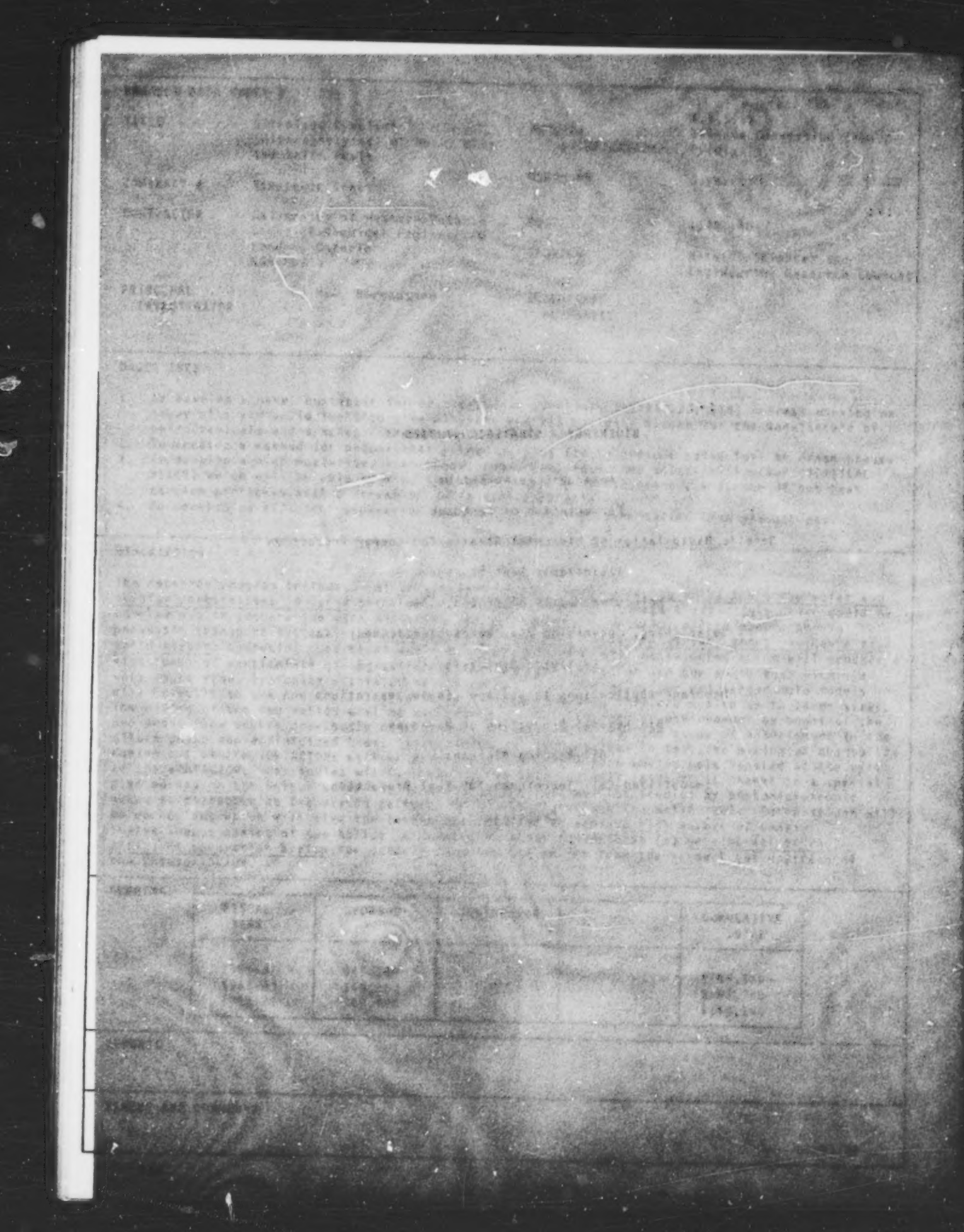
Membrane Applications in Gas and Liquid Separations

Biochemical Production of Hydrogen

Oil-Bearing Microbes

Immobilized Cell Techniques for Fuel Production

Cellulase



PROJECT DATA SHEET # 61

TITLE	Anaerobic conversion of cellulose to methane	**PROGRAM IDENTIFICATION**	4.3.7.1 Bioenergy Strategic Studies/ Anaerobic Fermentation
CONTRACT #			
CONTRACTOR	National Research Council 100 Sussex Drive Ottawa, Ontario. K1A 0R6	**DURATION**	1 April,1978 - continuing
		COST	$338,000
PRINCIPAL INVESTIGATOR	S.M. Martin Tel.: (613) 992-2367	**SPONSOR**	Biological Sciences and Bioenergy Program, NRC.
		SCIENTIFIC AUTHORITY	S.M. Martin Biological Sciences Sussex Drive Ottawa, Ontario. K1A 0R6 (613) 992-2367

OBJECTIVE

To examine in detail the biochemical and microbiological aspects of the conversion of biomass to fuels and chemical feedstocks.

DESCRIPTION

A focussed fundamental study of microbial fermentations whereby an understanding of the physiology of microbes and the manipulation of their environment may be used to optimize production of fuels and chemical feedstocks from biomass:

1. Optimization of the production of ethanol from steam-exploded aspen wood by the anaerobe Acetivibrio cellulolyticus, particularly through an examination of the effect of perturbations in the chemical and physical environment of the fermentation system;

2. Simulation in an in vitro co-culture system of a natural ecosystem (anaerobic digester) wherein a variety of microbial types are able to convert cellulose to methane and thereby study the microbial interactions involved in methanogenesis;

3. Examination of the effect of environmental changes on the production of ethyl acetate (an important feedstock and potential fuel extender) by the yeast Candida utilis;

4. Optimization of the microbial production of 2,3-butylene glycol to the extent that the process will be of economic significance.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	BIOLOGICAL SCIENCES	CUMULATIVE TOTAL
1980-81	$ 68,000		$ 35,000	$103,000
1981-82	$ 50,000		$ 25,000	$178,000
1982-83	$ 40,000		$ 40,000	$258,000
1983-84	$ 40,000		$ 40,000	$338,000

REPORTS

LAUBE V.M. and MARTIN S.M., Conversion of Cellulose to Methane and Carbon Dioxide by Triculture. Appl. Environ. Microbiol. 42: 413-420 (1980).

BREUIL C. and PATEL G.B., Composition of Methanospirillum hungatii GP1 during Growth on Different Media. Can. J. Microbiol. 26: 577-582. NRCC No. 18121.(1980)

KHAN W.W., SADDLER J.N., PATEL G.B., COLVIN J.R. and MARTIN S.M., Degradation of Cellulose by a Newly Isolated Mesophilic Anaerobe, Bacteriodaceae Family. FEMS Microbiology Letters 7 (1980), 47-50. NRCC # 17871.

BREUIL C. and PATEL G.B., Viability and Depletion of Cell Constituents of Methanospirillum hungatii GP1 During Starvation. Can. J. Microbial. 26: 887-892. NRCC # 18352. (1980)

STATUS AND COMMENTS

The original project on anaerobic conversion of cellulose to fuels has been expanded to include the production of ethyl acetate and 2,3-butylene glycol from sugars. S.M.M.

83/04/25

PROJECT DATA SHEET # 209

TITLE	Anaerobic Production of Fuels, Chemicals, Cellulolytic Enzymes & Sugars from Cellulosic Biomass	**PROGRAM IDENTIFICATION**	4.3.7.1 Bioenergy Strategic Studies/Anaerobic Fermentation
		DURATION	1979 -
CONTRACT #		**COST**	$510,000
CONTRACTOR	National Research Council Biological Sciences Sussex Drive Ottawa, Ontario K1A 0R6	**SPONSOR**	Divison of Biological Sciences & Bioenergy Program (Liquid Fuels Task) National Research Council
PRINCIPAL INVESTIGATOR	A.W. Khan W.D. Murray	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

To develop efficient and fast single-step anaerobic processes for the conversion of cellulose and hemicellulose to fuels and chemicals and to develop an economical process for the production of cellulolytic enzymes and sugars from cellulose.

DESCRIPTION

The focus of the work is on the development of reactor systems which would allow fast conversion rates in spite of the slow rates of growth of these microorganisms. The need for intermittent contact between cellulose and individual bacteria has made it difficult so far to devise a system with dense populations of cellulolytic microorganisms. The work has led over the years to the isolation of several new mesophilic cellulolytic anaerobes, to the development of a relatively simple anaerobic digestion process for the production of cellulolytic enzymes and to the development of a single step process for the conversion of cellulosic waste to sugars.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1979-80	$ 50,000			$ 50,000
1980-81	$ 60,000			$110,000
1981-82	$100,000			$210,000
1982-83	$140,000			$350,000
1983-84	$160,000			$510,000

REPORTS

MURRAY W.D., KHAN A.W., VAN DEN BERG L, Clostridium saccharolyticum Sp.Nov. A Saccharolytic Species from Sewage Sludge. Int. J. Syst. Bacteriol. 32, 132-135, 1982.

MURRAY W.D., KHAN A.W., Studies on the Conversion of Cellulosic Waste to Fuels and Chemical Feedstocks. Proc. 4th Bioenergy R&D Seminar. 487-489, 1982.

KHAN A.W., MURRAY W.D., Single Step Conversion of Cellulose to Ethanol by a Mesophilic Culture. Biotechnol. Lett. 4, 178-180, 1982.

STATUS AND COMMENTS

These lab scale processes require substantial upgrading to become commercially feasible. More recently a symbiotic culture consisting of two species of bacteria, one cellulolytic anaerobe belonging to the Bacteroidaceae family and the second, a saccharolytic anaerobe. Clostridium saccharolyticum sp.nov. were isolated from a methanogenic cellulose-enriched culture. This coculture converts a wide range of cellulosic materials to ethanol in a single step. Work to improve ethanol yields has led to the isolation of a mutant. This mutant, which is deficient in acetate kinase function, produces more ethanol and less acetic acid than the parent microorganism. Work is now underway at further strain improvement of both microbes with the objective of a one-step process improved in both the rate of cellulose hydrolysis and ethanol production. A.W.K. 83/04/26

PROJECT DATA SHEET # 335

TITLE	Acetone-Butanol Fermentation	PROGRAM IDENTIFICATION	4.3.7.1 Bioenergy Strategic Studies/ Anaerobic Fermentation
CONTRACT #	Strategic Grant	DURATION	3 years
CONTRACTOR	University of Guelph College of Biological Science Guelph, Ontario K1G 2W1	COST	$113,726
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	Cecil W. Forsberg	SCIENTIFIC AUTHORITY	

OBJECTIVE

It is proposed to enhance the anaerobic acetone and butanol fermentation systems of Clostridium acetobutylicum and C. butylicum. The program will require the development of laboratory batch and continuous cultivation systems as a prerequisite to the scale-up of the process to pilot and industrial dimensions.

DESCRIPTION

It is proposed to screen Clostridium strains for the ability to use hemicellulose and cellulose for growth and solvent production. Fermentation products will be measured using gas chromatographic techniques. Characterization of the xylanase and cellulolytic enzyme activities of the strains selected for further study will be conducted. Once appropriate strains of bacterium have been selected, their celluloiytic activity and solvent producing ability will be tested against a number of carbohydrate sources.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	EQUIPMENT	CUMULATIVE TOTAL
1982-83	$33,173		$14,799	$ 47,972
1983-84	$32,904			$ 80,876
1984-85	$32,850			$113,726

REPORTS

STATUS AND COMMENTS

Working in collaboration with L.N. Gibbins, Department of Microbiology. C.W.F.

83/04/29

PROJECT DATA SHEET # 116

TITLE	Fermentation of Pentoses by Yeasts	**PROGRAM IDENTIFICATION**	4.3.7.2 Bioenergy Strategic Studies/Fermentation of Pentoses
CONTRACT #		**DURATION**	1979-1983
CONTRACTOR	Molecular Genetics Group Division of Biological Sciences 100 Sussex Drive National Research Council	**COST**	$256,686
		SPONSOR	Bioenergy Program and the Division of Biological Sciences
PRINCIPAL INVESTIGATOR	H. Schneider		

OBJECTIVE

To obtain yeasts that can efficiently convert pentoses as well as hexoses into ethanol in order to increase alcohol yields in the fermentation of biomass sugars.

DESCRIPTION

Two approaches are being used. One centers on the study of some naturally occurring yeasts and their mutants which are able to convert the pentose D-xylose into ethyl alcohol. These studies are specifically aimed at producing organisms suitable for industrial use. They involve investigation of conditions for optimum ethanol yield and of the associated relevant biochemistry and genetics. The other approach centers on the use of genetic engineering methods. The objective is to transfer into a yeast heat, which is presently used industrially but which does not convert pentoses to ethanol, genes from other organisms which would allow the conversion to take place.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	BIOLOGICAL SCIENCES	CUMULATIVE TOTAL
1979-80	$20,262			$ 20,262
1980-81	$30,993		$12,500	$ 63,755
1981-82	$72,331		$13,000	$149,086
1982-83	$37,800		$69,800	$256,686

REPORTS

NEIRINCK L., MALESZKA R., SCHNEIDER H., Alcohol Production from Sugar Mixtures by Pachysolen tannophilus. Biotechnology and Bioengineering Symp. No. 12 (1982). In press. NRCC 20666.

SCHNEIDER H., WANG P.Y., JOHNSON B.F. and SHAPSIS C., Pentose Fermentation by Yeasts. Curr. Dev. Yeast Res., Adv. in Biotech. G.G. Stewart and I. Russell, eds. (1981) pp. 81-85, NRCC 18461.

SCHNEIDER H., WANG P.Y., CHAN Y.K. and MALESZKA R., Conversion of D-xylose into Ethanol by the 5. Yeast Pachysolen tannophilus. Biotech. Lett. 3, 89-92 (1981), NRCC 1909.

WANG P.Y. and SCHNEIDER H., Growth of Yeasts on D-xylose. Can. J. Microbiol. 26, 1165-1168, (1980), NRCC 18463.

WANG P.Y., JOHNSON B.F. & SCHNEIDER H., Fermentation of D-xylose by Yeasts Using Glucose Isomerase in the Medium to Convert D-xylose to D-xylulose. Biotechnol. Lett. 2, 273-278 (1980), NRCC 18377.

STATUS AND COMMENTS

At the bench top level, the problem of converting D-xylose into ethanol has been solved. With a mutant of a naturally occurring xylose fermenter, Pachysolen tannophilus, yields exceeding 90% of theoretical were obtained from a mixture of sugars similar to that encountered in commercial practice. The yield quoted is that for alcohol from the hexoses as well as the D-xylose present in the mixture. The key problem remaining is to get a yeast that can perform similarly under the conditions expected in commercial practice.

Progress has also been made using the genetic engineering approach by identification of the gene required (D-xylose isomerase), and by its successful cloning in a bacterium. Subsequent steps require transfer of this gene to a suitable yeast host, and its expression at a high level.

It is still too early to determine which of the approaches will lead more quickly to industrially useful strains. H.S. 83/04/26

PROJECT DATA SHEET # 333

TITLE	High Yield Pentose Fermenting Yeasts for Immobilized Cell Bioreactors	**PROGRAM IDENTIFICATION**	4.3.7.2 Bioenergy Strategic Studies/Fermentation of Pentoses
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	University of Western Ontario London, Ontario N6A 5B7	**COST**	$70,475
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	Marc-André Lachance Dept. of Plant Sciences	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

The objectives of the proposed project are to isolate and develop yeast strains capable of producing high yields of ethanol from D-xylose, and to develop appropriate immobilized cell bioreactor systems for the continuous fermentation of pentose rich materials to ethanol. First, natural substrates likely to harbor yeasts able to ferment pentoses will be screened for such yeasts. If appropriate, promising strains will be subjected to mutagenesis or hybridization with the intent of improving rates and yields.
Optimization of immobilization media and bioreactor design will then follow, and the economic feasibility of large scale ethanol production assessed. It is anticipated that pentose utilization will result in marked improvements in the economic value of fermentation of lignocellulosic materials.

DESCRIPTION (M.A. Lachance)

Part I It is proposed to sample yeast habitats likely to harbor xylose fermenting yeasts, namely tree exudates, and trees undergoing fungal decay. The following two approaches will be used. A general elective liquid medium containing xylose as sole carbon source will be used to enrich samples for yeasts able to assimilate or dissimilate pentose sugars. Enriched populations will then be examined, as well as further subjected to selection on high xylose semi-solid media supplemented with increasing amounts of ethanol. Alternatively, samples will also be enriched first for alcohol tolerant fermenting yeasts in a high glucose, high ethanol medium. Subsequent selection on xylose plates will complete the isolation.
Part II (A. Margaritis) The most promising yeasts derived from the first part of the project will be subjected to the following experimentation with regard to cell immobilization. (A) The immobilization of cells using a number of different gel matrices will be investigated, in order to optimize the specific activity and the stability of the immobilized cells. (B) The immobilized cell system developed in (A) will be assessed in a number of different bioreactor types. These will include (i) batch, (ii) repeated batch, (iii) fixed-bed, (iv) continuous stirred tank with retained immobilized cells, and (v) fluidized bed. (C) The optimum immobilized cell bioreactor system will be selected to carry out economic feasibility studies for a commercial scale ethanol plant, using lignocellulosic waste materials. Particular emphasis will be placed on assessing the impact of pentose utilization on the overall economics of ethanol production.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$16,715			$16,715
1983-84	$31,080			$47,795
1984-85	$22,680			$70,475

REPORTS

STATUS AND COMMENTS

Working in collaboration with A. Margaritis, Engineering Science.

83/04/29

PROJECT DATA SHEET # 334

TITLE	Two Stage Process for Conversion of Xylose to Ethanol	**PROGRAM IDENTIFICATION**	4.3.7.2 Bioenergy Strategic Studies/Fermentation of Pentoses
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	University of Waterloo Chemical Engineering Waterloo, Ontario N2L 3G1	**COST**	$105,180
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	Campbell W. Robinson	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

There is considerable interest in and potential for the use of fuel-grade ethanol as an alternative liquid fuel, especially when produced from forestry and agriculture lignocellulosic wastes which are relatively abundant in Canada. In order to achieve the maximum potential ethanol yield from such feedstocks, bioconversion of the pentose (xylose) in addition to the hexose (glucose) sugars is required. Present fermentation technology is based on conventional hexose-fermenting yeasts, which will not directly ferment xylose. A novel process is being developed in which xylose is converted to an intermediate chemical using an immobilized-enzyme bioreactor; the intermediate will be converted to ethanol in a packed-bed, immobilized hexose-fermenting yeast bioreactor. Several design and operating scenarios are being studied to determine the optimum process.

DESCRIPTION

No details available.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$32,700			$ 32,700
1983-84	$38,150			$ 70,850
1984-85	$34,330			$105,180

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 122

TITLE	The Construction of Microbial Strains for Energy Production	**PROGRAM IDENTIFICATION**	4.3.7.3 Strategic Studies/ Construction of Microbial Strains for Energy Production
CONTRACT #			
CONTRACTOR	Molecular Genetics Biological Sciences National Research Council Ottawa, Ont. K1A 0R6	**DURATION**	1979-continuing
		COST	$435,500 to date
		SPONSOR	Bioenergy Program and Division of Biological Sciences of NRC
PRINCIPAL INVESTIGATOR	V. Seligy Tel.: (613) 992-6055		
		SCIENTIFIC AUTHORITY	

OBJECTIVE

1. To provide a continuous watching brief that summarizes those recent findings, new techniques, and current trends in basic and applied genetic engineering that bear on the more efficient utilization of biomass in energy production.

2. To expand fundamental research on the expression, in yeast, of genes from other fungi.

DESCRIPTION

1. To conduct an extensive survey of literature dealing with recombinant DNA techniques in the utilization of biomass for energy production. To attend national and international conferences concerned with the role of biotechnology in energy production. To provide NRC's Division of Energy with a continuous watching brief concerned with trends and advances in this area.

2. The aim of this program is to use recombinant-DNA technology to extend the range of carbohydrate substrates that yeast can ferment to ethanol.

These projects are being carried out as part of an exploratory investigation of the usefulness of recombinant-DNA techniques in Biotechnology. Research is concerned, in particular, with the genetic engineering of yeast for more efficient utilization of biomass as a source of renewable energy.

Methods for transferring genes into yeast from other species or genera are now well established. However, the molecular basis of gene expression in yeast and other higher organisms is less well understood than in E. coli. The study of gene expression in yeast will emphasize genetic methods to increase specific enzyme synthesis and excretion by this organism. The enzymes of interest are amylase, B-glucosidase, exocellulases and endocellulases.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	BIOLOGY	CUMULATIVE TOTAL
1979-80	$10,000			$ 10,000
1980-81	$10,000		$130,000	$150,000
1981-82	$ 8,500		$192,000	$350,500
1982-83	$85,000			$435,500

REPORTS

The Molecualr Genetics Group prepared a literature review of recombinant DNA techniques in biomass conversion and submitted a report on the state-of-the-art and progress review.

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 199

TITLE	Novel Technology for Alcohol Production by Fermentation	**PROGRAM IDENTIFICATION**	4.3.7.3 Biomass Strategic Studies/ Genetic Manipulation
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	Applied Microbiology and Food Science University of Saskatchewan Saskatoon, Saskatchewan S7N 0W0	**COST**	$102,762
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	W.M. Ingledew	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

The overall objectives of this study are to improve economics of production of alcohol to be used as an alternate energy source in automobiles as gasohol, to develop a starch substrate-based single cell protein (fodder yeast) product, and to use genetic manipulation (engineering) to advance the application of biotechnology to world problems.

DESCRIPTION

This can only be done after the appropriate genetic engineering, and therefore the project in brief would involve:

1) routine screening of yeasts of a variety of genera for starch degradation (genetic) characteristics (completed 1979-80)
2) assessment of amylase-amyloglucosidase enzyme compliment
3) application of transformation and spheroplast fusion genetic procedures (Dr. G. Khachatourians)
4) assessment of resultant starch positive Saccharomyces yeasts for alcohol yield and SCP yield from starch. Appropriate yeasts should have high growth rates on starch, good enzyme production, high ethanol or biomass yields, and higher optimum temperatures to reduce cooling costs in propagators. Assessment of associative fermentation techniques
5) construction of a detailed economic study.

It is felt that this project may have future economic potential as a versatile yeast enterprise. For example, in a small brewery-type facility using "inexpensive" starch, end products (by-products) could include spent grains (animal feeds), ethanol, and primary or secondary yeasts. Yeasts made from starch (rather than imported molasses) could be active or inactive and could be used as food, feed, or for industrial use. The brewing, baking and distilling industries themselves could use the facilities of an independent yeast manufacturing plant which could act as a distribution center for custom-made yeast creams, press cakes or dried active yeasts. Perhaps a small localized plant could also help these industries with yeast inactivation, preservation and feed yeast preparation from spent yeasts.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$33,000			$ 33,000
1981-82	$36,762			$ 69,762
1982-83	$33,000			$102,762

REPORTS

WILSON J.J., KHACHATOURIANS G.G., INGLEDEW W.M., Protoplast Fusion in the Yeast Schwanniomyces alluvius. Mol. Gen. Genetics 186:85, 1982.

WILSON J.J., KHACHATOURIANS G.G., INGLEDEW W.M., Protoplast Fusion in Schwanniomyces alluvius. Fourth Bioenergy R&D Seminar. Winnipeg, 1982.

WILSON J.J., INGLEDEW W.M., Isolation and Characterization of Schwanniomyces alluvius Amylolytic Enzymes. Appl. Envir. Micro. 44:747, 1982.

STATUS AND COMMENTS

Working in collaboration with G.G. Khachatourians.

83/04/26

PROJECT DATA SHEET # 249

TITLE	Development of an Amylase Producing Yeast	**PROGRAM IDENTIFICATION**	4.3.7.3 Bioenergy Strategic Studies/Construction of Microbial Strains for Energy Production
CONTRACT #	31155-9-0623 (OSX80-00027)		
CONTRACTOR	ENS BIO Logicals 20 Victoria Street Suite 405 Toronto, Ontario M5C 2N8	**DURATION**	June 1980 - June 1983
		COST	$1,154,665
		SPONSOR	National Research Council PILP
PRINCIPAL INVESTIGATOR	P. Duck		
		SCIENTIFIC AUTHORITY	A. James National Research Council Sussex Drive Ottawa, Ontario K1A 0R6 Tele.: (613) 992-7833

OBJECTIVE

To develop an amylase producing fermentation yeast.

DESCRIPTION

Task 1 The identification of suitable amylases and selection of specific strains for donor gene. The development of yeast cloning methods.

Task 2 The isolation of the donor gene, its amplification and insertion into host organism.

Task 3 Measure gene expression, & test for stability, growth & conversion efficiency to ethanol.

Task 4 Optimization of process, secondary strain selection and modification. Selection of final strain and pilot scale growth trials.

Task 5 "Beer" distillation optimization and pilot scale optimization. Large scale trials and commercial assessment.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$298,200			$ 298,200
1981-82	$352,100			$ 650,300
1982-83	$410,700			$1,061,000
1983-84	$ 93,665			$1,154,665

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 250

TITLE	To Produce new Strains of Yeast via Genetic Engineering for Direct Conversion of Cellulose to Alcohol	**PROGRAM IDENTIFICATION**	4.3.7.3 Bioenergy Strategic Studies/Construction of Microbial Strains for Energy Production
CONTRACT #	31155-9-0642 (OSX80-00083)	**DURATION**	November '80 - November '83
CONTRACTOR	The Ontario Paper Company Ltd. 80 King Street P.O. Box 3026 Ste. Catherines, Ontario L2R 7G2	**COST**	$1,072,452
		SPONSOR	National Research Council PILP
PRINCIPAL INVESTIGATOR	R.H. Bryant	**SCIENTIFIC AUTHORITY**	A. James National Research Council Sussex Drive Ottawa, Ontario K1A 0R6 Tele.: (613) 992-7833

OBJECTIVE

To produce new engineered yeast clones capable of converting cellulose into ethanol directly.

DESCRIPTION

1. Analyse sugar content (mono and oligosaccharides - hexoses and pentoses) in spent sulfite liquor;
2. Select donor strains and isolate & characterize enzyme;
3. Isolate DNA and m RNA from donors;
4. Develop yeast vectors and establish a screening method;
5. Produce cDNA and test the effects of spent sulfite liquor on the enzyme system;
6. Test the effects of yeast on the activity and stability of the enzymes;
7. Screen the clone banks and carry out the charting of gene products;
8. Construct the vector hybrids with genes and transform genes into yeast;
10. Carry out laboratory fermentation and transformation trials;
11. Carry out organizational and sequential analysis of cloned genes;
12. Assay sugar and ethanol with spent sulfite liquor;
13. Prepare pilot plant feed yeasts (255 kg) and carry out pilot plant trials;
14. Assess commercial viability and prepare a report;

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$ 68,621			$ 68,621
1981-82	$286,669			$ 355,290
1982-83	$391,867			$ 747,157
1983-84	$325,295			$1,072,452

REPORTS

STATUS AND COMMENTS

Two proteins showing Avicelase activities have been isolated from S. commune. Their molecular weights are 65,000 and 68,000. A clone derived from transformation experiments with S. commune DNA has given positive response when hybridized to cDNA from enriched cellulose-grown cells. This clone has to be investigated further.

83/04/26

PROJECT DATA SHEET # 340

TITLE	Cloning and Expression of Cellulase Genes	**PROGRAM IDENTIFICATION**	4.3.7.3 Bioenergy Strategic Studies/ Genetic Manipulation of Microbial Strains for Energy Production
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	University of British Columbia Department of Microbiology Vancouver, British Columbia V6T 1W5	**COST**	$330,000
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	R.C. Miller	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

Cloned cellulase genes, from Cellulomonas fimi, will be transferred from the plasmid pBR322 to a plasmid in Bacillus subtilis. The intent is to develop bacterial strains which secrete the cellulases in large amounts. This means that the cloned genes must be linked to high level promoters of transcription, that the messenger RNA must be efficiently translated and that the host organism must be capable of transporting the enzymes.

DESCRIPTION

1. Transfer of genes to B. subtilis. The C. fimi cellulase genes have been cloned into the BamH1 site of pBR322. Thus, the first stage of the work will be to transfer the cloned fragments from the pBR322 derivatives to the BamH1 site of a B. subtilis vector.

2. Increased expression of cellulase Bacillus genes. Phage 29 has a strong promoter which is recognized by the B. subtilis RNA polymerase and is transcribed at a high level. The genes will be inserted down stream from this promoter at a Hind III site.

3. Transfer of genes to C. fimi. Conditions will be determined for transfer of this plasmid to C. fimi.

4. Genetic engineering of cellobiase. It is proposed to apply recombinant DNA techniques to the development of end-product resistant enzymes or achieve a method of end product (glucose) removal.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$110,000			$110,000
1983-84	$110,000			$220,000
1984-85	$110,000			$330,000

REPORTS

STATUS AND COMMENTS

Working in collaboration with D.G. Kilburn, R.A.J. Warren, Department of Microbiology. R.C.M. 83/04/29

PROJECT DATA SHEET # 321

TITLE	A Study of Organic Photovoltaic Cells Based on Photosynthesis Pigments	**PROGRAM IDENTIFICATION**	4.3.7.5 Bioenergy - Fundamental Studies/Molecular Models of Photosynthesis
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	University of Québec *Trois-Rivières, Québec* G9A 5H7	**COST**	$132,600
		SPONSOR	Natural Sciences and Engineering Research Council
		SCIENTIFIC AUTHORITY	
PRINCIPAL INVESTIGATOR	Roger M. Leblanc Centre de recherche en photobiophysique		

OBJECTIVE

To augment the efficiency and power of the organic photovoltaic cells by a better understanding of the photosynthetic constituents which could reduce the internal resistance of the system.

DESCRIPTION

In order to examine systematically the influence of the photosynthetic constituents on the photovoltaic properties of chlorophyll A at the multi-layer state, the following investigations are proposed:

1. the photovoltaic properties of the chlorophyll system A plus pheophytine A and the molar variations of the constituents
2. the photovoltaic properties of chlorophylls A & B
3. the photovoltaic properties of chlorophyll A plus plastoquinone
4. the photovoltaic properties of chlorophyll A plus lutein, a carotenoid pigment.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 48,000			$ 48,000
1983-84	$ 42,300			$ 90,300
1984-85	$ 42,300			$132,600

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 117

TITLE	Membrane Application in Gas and Liquid Separations	**PROGRAM IDENTIFICATION**	4.3.7.8 Bioenergy Strategic Studies/Membrane Applications in Gas and Liquid Separations
CONTRACT #			
CONTRACTOR	National Research Council Division of Chemistry Montreal Road Ottawa, Ont. K1A 0R6	**DURATION**	Oct. 1, 1979-continuing
		COST	$227,510
		SPONSOR	Bioenergy Program & Division of Chemistry, NRC
PRINCIPAL INVESTIGATOR	S. Sourirajan Tel.: (613) 993-2455		
		SCIENTIFIC AUTHORITY	n/a

OBJECTIVE

1. To produce high purity hydrogen, high Btu pipeline fuel and/or synthesis gas from gas mixtures.
2. To recover alcohol in high concentrations from fermentation liquids.
3. To fractionate mixtures of organic liquids arising in petroleum processes.

DESCRIPTION

An equation applicable for the analysis of experimental gas permeation data has been developed in terms of Knudsen, slip, viscous and sorbed flow through membrane pores. The utility of the above equation for predicting single- and mixed-gas transport through membranes is being investigated.

Using membranes made from a polyether imine sulfonourethane material, reverse osmosis separations of ethyl alcohol up to 79% have been accomplished from 10 wt.% ethyl alcohol-water feed solutions at 1000 psig. Using appropriate liquid chromatography data, the magnitudes of the interaction forces between alcohol and membrane material, and also the average pore sizes required for achieving different levels of ethanol separation in reverse osmosis are being estimated for different membrane materials.

Reverse osmosis separations of several inorganic and organic solutes in methanol solutions have been studied using cellulose acetate membranes. From liquid chromatography and reverse osmosis experiments, quantitative data on the interaction forces prevailing at the membrane material-methanol solution interfaces have been estimated. These data offer a physiochemical basis for reverse osmosis process design for the purification of industrial methanol. Further, fractionation of heptane-ethyl alcohol mixtures by permeation through cellulosic membranes is being investigated.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	DIVISION	CUMULATIVE TOTAL
1979-80	$18,510		$ 5,000	$ 23,510
1980-81	$51,000		$15,000	$ 89,510
1981-82	$51,000		$25,000	$165,510
1982-83	$37,000		$25,000	$227,510

REPORTS

FARNAND B.A., TALBOT F.D.F., MATSUURA T., and SOURIRAJAN S., Reverse Osmosis Separations of Some Organic and Inorganic Solutes in Methanol Using Cellulose Acetate Membranes. Ind. Eng. Chem. Process Design Development. In Press.

RANGARAJAN R., MAZID M.A., MATSUURA T., and SOURIRAJAN S., Studies on Gas Permeation Through Reverse Osmosis Membranes. Proceedings of the Fourth Bioenergy R&D Seminar, Winnipeg, Manitoba, March 1982. pp. 435-440.

MATSUURA T., TAKETANI Y., and SOURIRAJAN S., Reverse Osmosis Separation of Ethyl Alcohol in Aqueous Solutions Using Different Polymeric Membranes. Proceedings of the Fourth Bioenergy R&D Seminar, Winnipeg, Manitoba, March 1982. pp. 529-533.

FARNAND B.A., TALBOT F.D.F., MATSUURA T., and SOURIRAJAN S., Reverse Osmosis Separations of Organic and Inorganic Solutes in Methyl Alcohol Solutions. Proceedings of the Fourth Bioenergy R&D Seminar, Winnipeg, Manitoba, March 1982. pp. 535-539.

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 202

TITLE	Oil-Bearing Microbes: Microbial Systems for Liquid Fuels	**PROGRAM IDENTIFICATION**	4.3.7.10 Bioenergy Strategic Studies/Oil Bearing Microbes
CONTRACT #	Strategic Grant	**DURATION**	November 1980 to November 1983
CONTRACTOR	University of Toronto Toronto, Ontario M5S 1A4	**COST**	$117,705
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	M. Wayman Chemical Engineering		

OBJECTIVE

This research has as its major objective identifying conditions under which suitable microbes generate high concentrations of liquid hydrocarbons or other high energy organic compounds with fuel potential. The ultimate objective is to formulate a microbial system for the reduction of carbonate to liquid fuels to contribute to energy supply.

DESCRIPTION

We have identified two different sets of conditions leading to high lipid formation: glut, and starvation. In the presence of high sugar concentrations, some microorganisms develop very high concentrations of lipic clearly visible in the electron microscope. These occupy nearly all of the volume of the organisms. The other conditions for high lipid formation include P and/or N deprivation. Under these conditions growth is slow, and a useful process would have to be 2-stage: biomass production, and then oil generation.

The detailed research plan:

1. Arthrobacter Ak 19: complete studies of lipid generation and lipid composition through the life cycle; as a function of substrate concentration, pH, P deprivation, N deprivation; alternative C sources and a few other media variables.
2. Candida 107: to follow the patterns established with Arthrobacter Ak 19 (as in 1 above) to yield corresponding data.
3. Chlorella sp.: to obtain a fresh isolate of the Durum Lake Chlorella and review its growth requirements, energetics and metabolic products.
4. To establish, in the photomicrobiology laboratory, various configurations of interactive cultures of Chlorella (photosynthetics) and Arthrobacter Ak 19 or Candida 107.
5. To attempt to establish CO2 fixation by immobilized Chlorella cells.
6. To re-establish the Chromatium-Desulforistella S-based anaerobic system, and introduce immobilized Chromatium (photosynthetic) cells into the system, as granules, a column or some other physical configuration.
7. Based on the above, to design and build a larger scale installation to make oil-bearing microbes, and to study the mass and energy balances involved.
8. Based on 7, to design a full-scale plant.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$35,000			$ 35,000
1981-82	$38,990			$ 73,990
1982-83	$43,715			$117,705

REPORTS

LORA J.H., and WAYMAN M., Autohydrolysis of Aspen Milled Wood Lignin. Can. J. Chem., 58, (1980).

WAYMAN M., LORA J.H., Further Studies on Delignification of Wood by Autohydrolysis and Extraction Tappi, 62(9), 113-114 (1979).

LORA J.H., and WAYMAN M., Simulated Autohydrolysis of Aspen Milled Wood Lignin in the Presence of Aromatic Additives: Changes in Molecular Weight Distribution. J. Appl. Polym. Sci. 23, 1973 (1979).

WAYMAN M., and LORA J.H., Simulated Autohydrolysis of Aspen Milled Wood Lignin in the Presence of Aromatic Additives: Structural Modifications. J. Appl. Polym. Sci. 24, (1980).

WAYMAN M., ROUSSEAU J.D., KORMENDY A.G., Oil-Bearing Microbes: Micorbial Systems for Liquid Fuels. Contractors Meeting, March 30, 1982.

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 314

TITLE	Hydrocarbon Production from Algal and Fungal Biomass	**PROGRAM IDENTIFICATION**	4.3.7.10 Bioenergy - Fundamental Studies/Oil-Bearing Microbes
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	University of Waterloo Dept. of Biology Waterloo, Ontario N2L 3G1	**COST**	$143,000
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	C.I. MAYFIELD	**SCIENTIFIC AUTHORITY**	

OBJECTIVES

To optimize the lipid production of certain microbes and algae and to develop a procedure for extracting this lipid.

DESCRIPTION

Studies on the use of cheap carbohydrate or cellulosic energy sources, either as direct additions to the growth medium or as energy sources for bacterial or fungal growth with consequent CO_2 production, will be carried out. The possibility that nitrogen fixation by Azotobacter sp. using these substrates (or their decomposition products) could provide fixed nitrogen for algal biomass production systems will also be investigated. Nitrogen-fixing Azotobacter cells have a substantial membrane component so as to provide respiratory protection (O_2 removal) for the O_2 sensitive nitrogenase enzyme system, and thus wil serve to enrich the lipid hydrocarbon yield of the biomass system.

Thus the proposed study would investigate algal biomass production and attempt to achieve high lipid contents in the cells. Release of the lipid hydrocarbon equivalents of the biomass following homogenization and treatment with free radicals would be the other main objective of this aspect of the study.

We will attempt to optimize growth rate and lipid (membrane lipid and triglyceride lipid) production in a number of well-known fast-growing fungi (e.g. Chaetomium cellulolyticum, Chrysonilia sitophila).

All membranes are a rich souce of straight chain fatty acids and can be a substantial fraction of the biomass of cells, particularly eukaryotic cells.

Both ozone treatment and direct free-radical treatment with O_2 from KO_2 will be used as a means of releasing the hydrocarbon equivalents of membranes and triglycerides from algal and fungal biomass. These treatments also cause some lipid peroxidation. However, the balance between lipid peroxidation and de-esterification can be controlled by varying the intensity and duration of the free radical treatment. Release of free fatty acids and products of lipid peroxidation from the membrane and triglyceride elements of biomass will be monitored by gas-liquid chromatography.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 47,000			$ 47,000
1983-84	$ 48,000			$ 95,000
1984-85	$ 48,000			$143,000

REPORTS

STATUS AND COMMENTS

Working in collaboration with W.B. Kendrick and J.E. Thompson, Dept. of Biology.

83/04/29

PROJECT DATA SHEET #	200		
TITLE	Continuous Ethanol Production Using Immobilized Cells of *Zymomonas mobilis*	**PROGRAM IDENTIFICATION**	4.3.7.11 Bioenergy Strategic Studies/Immobilized Cell Techniques for Fuel Production
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	Faculty of Biochemical Eng. University of Western Ontario London, Ontario N6A 5B9	**COST**	$85,635
PRINCIPAL INVESTIGATOR	A. Margaritis	**SPONSOR**	Natural Sciences and Engineering Research Council

OBJECTIVE

A novel approach is proposed where immobilized cells of *Zymomonas mobilis* are to be used as catalysts for the continuous production of ethanol from carbohydrates. The proposed immobilized cell bioreactor systems have many potential advantages when compared to conventional batch fermenter systems used today for alcohol production.

DESCRIPTION

1. Optimization of Immobilization Methods
   a) adsorption or bonding of cells to sand particles
   b) entrapment of cells in polyacrylamide gel and carrageen polymers
   c) microencapsulation of cells using different polymeric materials.

2. Bioreactor Development and Optimization
   The following bioreactor systems will be investigated:
   a) continuous packed bed column bioreactor
   b) continuous stirred tank bioreactor with micro screens
   c) fluidized bed bioreactor using cells immobilized on solids with specific gravity between 2 and 3
   d) ordinary batch and continuous stirred tank bioreactor using freely suspended cells.

3. Experimental Parameters
   a) flow rate and glucose concentration of feed; b) ethanol concentration; c) ethanol yields d) effects of temperature and pH; e) half-life of the immobilized cells under different operating conditions; f) ethanol production per unit bioreactor volume; g) contamination and sterilization problems of bioreactor systems; h) maximum glucose and ethanol concentrations which inhibit ethanol production.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$27,000			$ 27,000
1981-82	$30,635			$ 58,135
1982-83	$27,500			$ 85,635

REPORTS

Related publications as of 1989.

MARGARITIS A., ROWE G., BALTUS T., Enzymatic Hydrolysis of Rice Hulls. Develop. Ind. Microbiol., Vol. 21, 1980.

MARGARITIS A., KENNEDY K., The Application of an Air-Lift Fermenter in the Production of Biosurfactants. Develop. Ind. Microbiol., Vol. 21, 1980.

MARGARITIS A., CREESE E., Toxicity of Surfactants in the Aquatic Environment: A Review. In "Waste Treatment and Utilization" editors Moo-Young M., and Farguhar G.J., pp. 445-462, Pergamon Press, Oxford, England, 1980.

MARGARITIS A., ZAJIC J.E., GERSON D.F., The Production and Surface Active Properties of Microbial Surfactants. Biotech. Bioeng. Vol. 21, No. 7, 1151-1162, 1979.

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 349

TITLE	Immobilized Systems in Biotechnological Processes	**PROGRAM IDENTIFICATION**	4.3.7.11 Bioenergy Strategic Studies/ Immobilized Cell Techniques for Fuel Production
CONTRACT #		**DURATION**	1982 continuing
CONTRACTOR	Microbiology Group Division of Biological Sciences National Research Council 100 Sussex Drive Ottawa, Ontario	**COST**	$85,000 to date
		SPONSOR	Bioenergy Program (Liquid Fuels Task) and Division of Biological Sciences, NRC
PRINCIPAL INVESTIGATOR	I. Veliky & F.W. Welsh		

OBJECTIVES

To apply whole cell and enzyme immobilization techniques for the production of biological products.

DESCRIPTION

1. To study immobilization techniques such as attachment on porous materials. Treatment methods for increasing attachment will also be investigated. Entrapment or encapsulation techniques for the production of ethanol, butanol and acetone will be studied. This will include the examination of the principles of diffusion of products and substrate.

2. To study production of butanol by Clostridium spp. and examine the butanol toxicity. Nutritional studies will include macro and micro nutrients.

3. To study the production of cellobiase by Tricoderma spp. This will include the continuous production of cellobiase by immobilized cell techniques.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	BIOLOGICAL SCIENCES	CUMULATIVE TOTAL
1982-83	$ 35,000		$50,000	$ 85,000

REPORTS

VIDOLI R., YAMAZAKI H., HASIM A., VELIKY I.A., A Novel Procedure for the Recovery of Hybrid Products from Protoplast Fusion. Biotechnology Letters, Vol. 4 (12) pp 781-784. 1982

WILLIAMS R.E., VELIKY I.A., Alcohol Production by Microorganisms Immobilized in Metal Ion Gelled Polysaccharides. Proc. of the Fourth Miami International Conference on Alternative Energy Sources. Ed. T. Nejat Veziroglu. 1982.

WILLIAMS R.E. and VELIKY I.A., The Use of Immobilized Cells in Fermentations. Proceedings of the Fourth Bioenergy R&D Seminar, pp. 481-484, Winnipeg, Manitoba. 1982.

STATUS AND COMMENTS

83/05/02

PROJECT DATA SHEET # 277

TITLE	Solid-State Fermentation of Poplar Wood	**PROGRAM IDENTIFICATION**	4.3.7.12 Bioenergy Strategic Studies/Cellulase
CONTRACT #	31155-2-2844	**DURATION**	December 1982 to December 1983
CONTRACTOR	Queen's University Dept. of Chemical Engineering Kingston, Ontario K1G 3Z5	**COST**	$46,302
		SPONSOR	National Research Council (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	Derek H. Bone	**SCIENTIFIC AUTHORITY**	W.M. Lyse Morisset National Research Council Montreal Road Building M-55, Room 381 Ottawa, Ontario K1A 0R6 Tel.: (613) 993-1342

OBJECTIVE

To examine six filamentous fungi for their ability to produce cellulolytic enzymes when growing on poplar wood in solid-state fermenters and to identify the optimal environmental conditions for cellulase production.

DESCRIPTION

The following factors will then be studied in detail:

1. Type of fungi: six widely different types will be selected, including Trichoderma reesei, CRM-9414 and E-581.
2. Ratios of weight of wood substrate to volume of nutrient solution.
3. Temperature
4. Wood pre-treatment: steam exploded wood will be compared with wood shavings.

Initially, tests will be made to determine the best way of preparing and applying inoculum, satisfactory nutrient requirements and the required buffering capacity for pH control.

Experiments will be conducted using 500 ml jars as growth chambers partially filled with alkali-treated poplar wood shavings.

Enzyme production will be related to soluble protein content to estimate changes in specific cellulolytic activities. Dry weight loss and solubilities will yield information on the extent of cellulose degradation and rates of growth of fungi.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$14,000			$14,000
1983-84	$32,302			$46,302

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 337

TITLE	Regulation of Cellulase Production in Industrially Important Microorganisms	**PROGRAM IDENTIFICATION**	4.3.7.12 Bioenergy Strategic Studies/Cellulase
		DURATION	2 years
CONTRACT #	Strategic Grant		
CONTRACTOR	University of Ottawa Dept. of Biology Ottawa, Ontario K1n 6N5	**COST**	$54,800
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	Donn J. Kushner	**SCIENTIFIC AUTHORITY**	

OBJECTIVE

The production of cellulolytic enzymes will be studied in a number of bacteria and fungi, with special attention to the mechanisms by which the synthesis of these enzymes are regulated, including induction by cellulose and other substrates, and repression by glucose and other end products. Attempts will be made to obtain strains that produce more cellulases, and/or those in which the synthesis of these enzymes is less subject to repression by end products. Activity of the strains studied will be tested first on purified celluloses, then on different wood products. The possibility that the organisms studied contain substantial amounts of cellulases in cell-bound forms will be studied.

DESCRIPTION

The work proposed is to be carried out in collaboration with Dr. J. Saddler of FORINTEK Canada Corp., Ottawa.

1. Selection of microorganisms will include: Trichoderma sp. because of their high cellulolytic ability. Cellvibrio gilvus, as a model bacterium, which has already been studied and which would serve as a good organism to investigate selection of more cellulolytic or deregulated mutants. Other microorganisms, such as Cellulomonas and the anaerobe Clostridium thermocellum will also be studied.
2. With the microorganisms chosen, experiments will be carried out to determine whether cellulose and its different forms and derivatives (crystalline and amorphous cellulose; CMC) induce formation of enzymes of the cellulase complex, and if contact between the cell and the insoluble substrates is necessary for this induction. It will also be determined if glucose and cellobiose repress formation of the above enzymes.
3. With the microorganisms tested, especially those that produce high levels of cellulases, the possibility will be examined that cellulose stimulates growth, even in a rich complex medium, as has been found for C. gilvus and if, under these conditions, the addition of glucose inhibits growth. It is likely that any mutants which are no longer repressed by the end products of glucose digestion might grow faster in a system containing cellulose fibres and might come to dominate the population.
   Experiments will at first be carried out in batch cultures, then in continuous cultures.
4. If more active, or less repressible mutants are found and prove to be stable, further experiments will be performed using different cellulose compounds and wood products, with the aim of attaining a commercially acceptable microbial degradation of cellulose. Among the substrates to be tested in this work are: Commercial cellulose such as Avicel, Whatman Cf cellulose, CMC and pretreated wood and agricultural residues such as steam exploded aspen, solvent extracted aspen and a variety of pretreated agricultural residues.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$28,300			$28,300
1983-84	$26,500			$54,800

REPORTS

STATUS AND COMMENTS

Dr. Saddler will supply most of the microorganisms to be used. Also the first experiments on anaerobic cellulose digesters will be done at FORINTEK. D.J.K. 83/04/29

PROJECT DATA SHEET # 341

TITLE	Aerobic Production of Fuels, Chemicals, Cellulolytic Enzymes and Sugars from Wood Cellulose	**PROGRAM IDENTIFICATION**	4.3.7.12 Bioenergy - Fundamental Studies/Cellulase
CONTRACT #		**DURATION**	1981 - continuing
		COST	$255,000
CONTRACTOR	National Research Council Division of Biological Sciences 100 Sussex Drive Ottawa, Ontario K1A 0R6	**SPONSOR**	Division of Biological Sciences & Bioenergy Program National Research Council
PRINCIPAL INVESTIGATOR	A.W. Khan, W.D. Murray S.J.B. Duff, M.F. Podruzny, L. van den Berg	**SCIENTIFIC AUTHORITY**	N/A

OBJECTIVE

To develop a fermentation system for the economical large scale production of cellulolytic enzymes by Trichoderma spp. preferably using wood as a substrate.

DESCRIPTION

The work includes: (a) study of factors limiting cellulase production in submerged cultures (agitation, aeration, etc.) and in solid state cultures; (b) study and development of techniques to obviate contamination and mutation problems in large scale reactors without resorting to stringent aseptic and sterile techniques; (c) development of reactors optimizing conditions for enzyme production and cellulose hydrolysis.

Some work will also be done to develop reactors for the enzymatic hydrolysis step.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 75,000			$ 75,000
1983-84	$180,000			$255,000

REPORTS

STATUS AND COMMENTS

Preliminary work has indicated that oxygen transfer is limiting under most conditions reported in the literature.

83/04/29

PROJECT DATA SHEET # 348

TITLE	Bioconversion of Lignocellulosics by *Streptomyces flavogriseus*	**PROGRAM IDENTIFICATION**	4.3.7.12 Bioenergy Strategic Studies/Cellulase
		DURATION	1982 continuing
CONTRACT #			
CONTRACTOR	Microbiology Group Division of Biological Sciences National Research Council 100 Sussex Drive Ottawa, Ontario	**COST**	$69,400
		SPONSOR	Bioenergy Program and Division of Biological Sciences, NRC
PRINCIPAL INVESTIGATOR	K. Johnson & C.R. MacKenzie		

OBJECTIVES

1) create biotechnological systems for the enzymic saccharification of lignocellulosics, and

2) to conduct fundamental studies directed towards an understanding of the molecular mechanisms of enzymic cellulose and xylan hydrolysis in bacterial systems.

DESCRIPTION

An intensive physiological and enzymic study which addresses the common first-step of processes designed for biological conversion of lignocellulosics to fuels and chemical feedstocks: the conversion of cellulose and xylans to fermentable sugars. The over-all objectives of this programme are to:

1. Determine optimum growth conditions for production of cellulase and xylanase activities and investigate the optimization of glucose isomerase.

2. Isolate, purify and characterize the cellulases.

3. Isolate, purify and characterize the xylanases.

4. Conversion of enzymic hydrolysates of lignocellulosics to ethanol by *Schwanniomyces* spp.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	BIOLOGICAL SCIENCES	CUMULATIVE TOTAL
1982-83	$ 39,400		$30,000	$ 69,400

REPORTS

STATUS AND COMMENTS

1. Have obtained optimum growth conditions for production of cellulase and xylanase activities.

2. Several extracellular cellulases have been separated of which 4 display endoglucanase activity while the fifth is either on exoglucanase or cellobiase.

3. Three distinct extracellular xylanases have been isolated.

4. Acid swollen cellulose was extensively hydrolysed at concentrations up to 10% while crystalline cellulose was more resistant.

83/04/29

SOCIO-ECONOMIC-TECHNICAL STUDIES

Social Infrastructure

Technology Assessment

Economic Assessment

Information

Legal Studies

PROJECT DATA SHEET # 177

TITLE	Forest Product Based Sacrificial Agents for Enhanced Oil Recovery	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic Technical Studies/Technology Assessment
CONTRACT #	KL229-1-4117 (OSS81-0047) C-191	**DURATION**	April 1981-March 1983
		COST	$152,750
CONTRACTOR	B.C. Research 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	R.J. Neale Place Vincent Massey Hull, Que.
PRINCIPAL INVESTIGATOR	John Howard Tel.: (604) 224-4331	**TECHNICAL LIAISON OFFICER**	J.F.G. Mackay Forintek Canada Corporation Western Laboratory 6620 NW Marine Drive Vancouver, B.C. V6T 1X2

OBJECTIVE

To evaluate suitable silvichemicals and their appropriate derivatives as sacrificial agents for use in tertiary oil recovery systems.
To approach oil companies actively developing surfactant dependent enhanced oil recovery processes for further evaluation of these sacrificial agents (especially in the field).
To approach chemical marketing companies with a vested interest in marketing effective sacrificial agents to promote further sale of their surfactants.

DESCRIPTION

Isolation of Sacrificial Agents

The following byproducts of the forest products industry are thought to have potential as starting materials for sacrificial agent manufacture:

- Kraft black liquor lignin and carbohydrate components.
- Spent sulphite liquor (red liquor) lignin and carbohydrate components.
- "E"-stage liquor from both Kraft and sulphite pulp bleaching stages.
- Prehydrolysis liquor from pretreatment of both chips for pulping and sawdust for conversion into hardboard (Masonite).

The evaluation procedure will take the following form. Well defined montmorillonites will be exposed to solutions of the potential silvichemical sacrificial agents. The adsorption of these agents on the clays can be followed by ultra-violet adsorption spectroscopy where suitable chromophores are present or chemically by total organic carbon analysis. The treated clay will then be exposed to solutions of de-oiled petroleum sulfonates of differing equivalent weights covering the range normally used in oil recovery.
Adsorption of surfactant will be monitored by sulfonate analysis. Comparison of surfactant adsorption with and without pretreatment with silvichemical derivatives will be carried out to identify particular derivatives having potential as sacrificial agent and to ascertain general correlations between the ability of a derivative to function as a sacrificial agent and its physical characteristics (charge, hydrophilic/lipophilic balance, etc.).
Initially experiments will be carried out in sodium chloride solution using sodium montmorillonite. Later the performance of selected sacrificial agents will be evaluated on calcium montmorillonite which has the potential to act as a source of Ca^{2+} ions capable of precipitating the petroleum sulfonates. A sacrificial agent should have the ability to not only coat the clay surfaces to prevent sulfonate adsorption but to contain the Ca^{2+} ions within the clay structure.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$87,450			$ 87,450
1982-83	$65,300			$152,750

REPORTS

STATUS AND COMMENTS

The results look promising and a patent application is being filed. Bionergy Program - 83/04/26

PROJECT DATA SHEET # 178

TITLE	Technical Assessment of Downdraft Gasifiers	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assessement.
CONTRACT #	KL229-1-4118 (OSS81-00022) C-197	**DURATION**	April 1981 - May 1983
CONTRACTOR	Dept. of Chemical Engineering Queen's University Kingston, Ontario. K7L 3N6	**COST**	$184,611
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	D.W. Bacon Tel.: (613) 547-3202	**SCIENTIFIC AUTHORITY**	R.P. Overend National Research Council Montreal Road Room 206 Building M-50 Ottawa, Ontario. K1A OR6

OBJECTIVE

To develop and test quantitative methods to assess the operation and design of down-draft gasifiers

DESCRIPTION

1. Mechanistic and empirical models of down-draft wood gasifiers;
2. Computer simulation programs incorporating these models;
3. Experimental design and data analysis procedures to obtain data and extract information efficiently for assessing and improving the operation of down-draft wood gasifiers;
4. Procedures for establishing limits on the reliability and acceptability of data from gasifier operation.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$86,380			$ 86,380
1982-83	$90,689			$177,069
1983-84	$ 7,542			$184,611

REPORTS

Work in Progress.

STATUS AND COMMENTS

Working in collaboration with J. Downie and C.C. Hsu.

83/04/14

PROJECT DATA SHEET # 258

TITLE Uniformity of Product of Iotech's Steam Explosion Pretreatment

CONTRACT # 31155-2-2615 (OSX82-00023)

CONTRACTOR Iotech Corporation Limited
400 Hunt Club Road
R.R. # 5
Gloucester, Ontario
K1G 3N3

PRINCIPAL INVESTIGATOR P.W. Smith

PROGRAM IDENTIFICATION 4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.

DURATION May 1982 - December 1982

COST $21,499

SPONSOR National Research Council

SCIENTIFIC AUTHORITY wm L. Morisset
National Research Council
Bioenergy Program
Building M-55
Room 381
Ottawa, Ontario
K1A 0R6

OBJECTIVE

To produce steam exploded wood in order to determine the uniformity of the product from steam explosion pretreatment.

DESCRIPTION

To prepare representative samples of steam exploded wood for independent analysis.

Composite samples of daily production for fifteen days are to be provided, representing two different sets of operating conditions.

Hourly samples are to be provided for one day.

Samples of poplar chips used as starting material are to be provided.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$21,499			$21,499

REPORTS

Final report submitted December 1982.

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 262

TITLE	Analysis of Wood Chips and Iotech Steam Exploded Wood	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/ Technology Assess.
CONTRACT #	31155-2-2841 (OSX82-00070)	**DURATION**	1982-83
CONTRACTOR	Rutgers University Cook College Department of Biochemistry and Microbiology P.O. Box 231 New Brunswick, New Jersey U.S.A. 08903	**COST**	$4,700
		SPONSOR	National Research Council (Liquid Fuels Task)
		SCIENTIFIC AUTHORITY	wm L. Morisset National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tele.: (613) 993-1342
PRINCIPAL INVESTIGATOR	Douglas E. Eveleigh Tele.: (201) 932-9829		

OBJECTIVE

To assess the uniformity of characteristics of samples of wood chips and steam exploded wood.

DESCRIPTION

Composition susceptibility to enzymatic degradation and saccharification potential will be determined for samples of wood chips and steam exploded wood provided by IOTECH.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$4,700			$4,700

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 265

TITLE	Assessment of Iotech Steam Exploded Wood	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	31155-2-2840 (OSX82-00085)	**DURATION**	August 1982 - March 1983
CONTRACTOR	Forintek Canada Corporation Eastern Laboratory 800 Montreal Road Ottawa, Ontario K1G 3Z5	**COST**	$33,823
		SPONSOR	National Research Council (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	J.N. Saddler	**SCIENTIFIC AUTHORITY**	wm L. Morisset National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tele.: (613) 993-1342

OBJECTIVE

To assess the uniformity of characteristics of samples of wood chips and steam exploded wood provided by IOTECH.

DESCRIPTION

The following analyses will be performed on samples provided:

1. Proximate and ultimate analysis, potential glucose and xylose, pentosan, lignin and cellulose.
2. Susceptibility to enzymatic hydrolysis and analysis of breakdown products, monosaccharides and reducing sugars.
3. Toxicity tests by growth of S. cerevisiae and Z. mobilis on enzymatically hydrolyzed fractions.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$33,823			$33,823

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 268

TITLE	Update on Wood Liquefaction Technology	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	31155-2-2845 (OSX82-00110)	**DURATION**	October 1982 to January 14, 1983
CONTRACTOR	SNC Inc. 1, Complexe Desjardins P.O. Box 10 Desjardins Postal Station Montréal, Québec H5B 1C8	**COST**	$29,837
		SPONSOR	National Research Council
		SCIENTIFIC AUTHORITY	R.P. Overend National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342
PRINCIPAL INVESTIGATOR	J.M. Moffatt & J.C. Dhawan		

OBJECTIVES

1. To ascertain the current status and recent progress of each known leading research group.
2. To establish an up-to-date state-of-the-art conceptual process design using the data base developed for ENFOR C-69 and evaluate changes in feasibility and economics.
3. To examine the costs and implications of meeting the hydrogen requirements of such processes.

DESCRIPTION

The current work of the groups who participated in the 'Specialists Meeting in Biomass Liquefaction' held at Saskatoon, Canada, on February 16 & 17, 1982 (Published by the U of Saskatchewan) was updated on the basis of telex questions and phone & visit responses.

The University of Toronto rapid pyrolysis process (Data sheet 325) was used as a design basis for the development of a conceptual flow sheet costed by means of inflation factors on the data used in ENFOR C-69.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83 1983-84	$29,837			$29,837

REPORTS

MOFFATT J.M., DHAWAN J.C., The SNC Group, Update on Wood Liquefaction Technology. Montreal, Québec, December 31, 1982. (Available on Microfiche from CISTI)

STATUS AND COMMENTS

The report showed that the R&D on wood liquefaction since C-69 had resulted in about a 30% increase in liquid yield and 30% less plant capital investment. If chemicals such as phenol and acetic acid are marketed as co-products the fuel oil produced would be competetively priced against the international oil price for when the wood feedstock is at $20/ODt.

83/04/27

PROJECT DATA SHEET # 266

TITLE	Analysis of Iotech Steam Exploded Wood	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	31155-2-2629 (OSX82-00062)	**DURATION**	July 1982 - January 1983
CONTRACTOR	Bondar-Clegg & Company Ltd. 764 Belfast Road Ottawa, Ontario K1G 0Z5	**COST**	$1,440
		SPONSOR	National Research Council (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	R. Sawyer	**SCIENTIFIC AUTHORITY**	wm L. Morisset National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tele.: (613) 993-1342

OBJECTIVE

To assess uniformity of characteristics of samples of wood chips and steam exploded wood provided by IOTECH.

DESCRIPTION

To perform proximate analyses of samples provided.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$1,440			$1,440

REPORTS

Final report received, January 1983. W.M.L.M.

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 282

TITLE	Evaluation of Approaches to the Hydrolysis of Lignocellulosics from Canadian Hardwoods	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	31155-2-2804 (OSX82-00195)	**DURATION**	February 1983 to August 1983
CONTRACTOR	Forintek Canada Corporation Eastern Laboratory 800 Montreal Road Ottawa, Ontario K1G 3Z5	**COST**	$99,268
		SPONSOR	National Research Council (Liquid Fuels Task)
PRINCIPAL INVESTIGATOR	J. Saddler	**SCIENTIFIC AUTHORITY**	W.M. L. Morisset National Research Council Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tele.: (613) 993-1342

OBJECTIVE

To evaluate some yet unexplored aspects of hardwood hydrolysis with a view to identifying more clearly the most promising candidates for future research.

DESCRIPTION

Phase I — Use of Forintek equipment and technical services to evaluate scale up of enzymatic hydrolysis of lignocellulosics.

a) Growth of Trichoderma 9414 and E-58, before and after alkali treatment, in the Microferm fermenter to study enzyme production of pre-treatment poplar wood as a function of oxygen & agitation rate.
b) Technical evaluation of problems of reduced enzyme production in large fermenters.
c) Study of feasibility of carrying out combined enzymatic hydrolysis & fermentation in a batch and semi-batch process.

Phase II — Evaluation of existing and possible new methods of acid hydrolysis of hardwoods.

a) Evaluate the experience with dilute and concentrated acid hydrolysis of hardwoods.
b) Assess the use of hydrofluoric acid (HF) as an hydrolyzing agent.
c) Assessment of high-temperature, acid-catalyzed treatment of aspen in aqueous or or organic medium.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$50,000			$50,000
1983-84	$49,268			$99,268

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 312

TITLE	Evaluation of an Anaerobic Digester	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	01843-1-ER19 (OSZ81-00143)	**DURATION**	16 months
CONTRACTOR	Urgel Delisle & Assoc. 426 chemin des Patriotes St. Charles sur Richelieu Québec B.P. # 60 J0H 2G0	**COST**	$75,895
		SPONSOR	Agriculture Canada
		SCIENTIFIC AUTHORITY	Roger Chagnon Agriculture Canada Research Station 90 Lajeunesse Street P.O. Box 457 Saint-Jean, Québec J3B 6Z8 Tel.: (514) 346-4494
PRINCIPAL INVESTIGATOR	M. Cournoyer		

OBJECTIVES

DESCRIPTION

1. Evaluate certain parameters which can be used to identify and control the health of the digester.
2. Evaluate the actual production of the digester, the quality of the biogas and the stability of operation at 35°C.
3. To examine the use of biogas for electrical generation.
4. To evaluate the effectiveness of the system for heat recovery.
5. To evaluate a synthetic material for methane storage.
6. To evaluate equipment for stripping water and hydrogen sulfide from the biogas.
7. To study the constraints imposed by the digester on the operations of the farm.
8. To evaluate the systems profitability.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$55,000			$55,000
1983-84	$20,895			$75,895

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 313

TITLE	Comparison of Enzymatic & Acid Hydrolysis & Fermentation Methods of Steam Treated Lignocellulosic Agri. Residues	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	01843-1-EL11 (OSZ81-000151)	**DURATION**	March 23, 1982 to March 31, 1984
		COST	$426,011
CONTRACTOR	Forintek Canada Corp. Eastern Laboratory 800 Montreal Road Ottawa, Ontario K1G 3Z5	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
		SCIENTIFIC AUTHORITY	E. Manolakis Engineering and Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671
PRINCIPAL INVESTIGATOR			

OBJECTIVES

1. To obtain separate product streams of lignin, cellulose and hemi-cellulose and their composite sugars from agricultural residues through the use of steam, acid, and enzymes.
2. To ferment sugars derived from cellulose and hemicellulose through a variety of methods.
3. Perform an economical & technical analysis of the methods with respect to the end products.

DESCRIPTION

1. Using steam explosion with and without acid, and various extraction techniques, obtain separate product streams of lignin, hemicellulose and cellulose and of their derived sugars. Feedstocks include barley straw, wheat straw, corn stover and others.
2. Hemicellulose and cellulose will be hydrolysed by different chemical and enzymatic methods such as: acid, cellulase enzyme systems, and immobilized cell reactors.
3. The contractor will investigate and optimize the fermentation of sugars in batch (or continuous) and immobilized cell reactors using Zymomonas mobilis.
4. The contractor will optimize the fermentation of all sugar streams including mixtures of hexose and pentose streams to solvents by utilizing single or mixed cultures of Clostridium acetobutylicum and C. butylicum (acetone, butanol).
5. The contractor will attempt to induce hemicellulase activity in K. pneumoniae and Clostridium sp. If this is successful, the contractor will investigate the direct hydrolysis/fermentation of hemicellulose by these organisms.
6. The contractor will investigate the simultaneous saccharification and fermentation of hemicellulose, cellulose, and hemicellulose/cellulose mixtures using a combination of various enzyme systems and organisms such as Zymomonas, Saccharomyces, Clostridium and Klebsiella.
7. The contractor will investigate mixed culture fermentation and hydrolysis/fermentation of hemicellulose, cellulose and mixtures thereof for the production of ethanol by Clostridium thermocellum in co-culture with C. thermosaccharolyticum or C. thermohydrosulfuricum.
8. The contractor will perform detailed studies on continuous cultivation and solvent production on some of the promising systems investigated above.
9. The contractor will initiate studies to determine if an immobilized cell (gel beads of fixed film) reactor can be practically devised to accommodate both cellulolytic organisms and ethanol or power solvent producers.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 10,569			$ 10,569
1982-83	$199,486			$210,055
1983-84	$216,016			$426,011

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 322

TITLE	Technical/Economic Study of Farm and Industrial Scale Fuel Ethanol Plant Employing Vapour Compression Distillation	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	01843-2-EL16 (OSZ82-00044)	**DURATION**	June 21, 1982 to June 1983
		COST	$81,185
		SPONSOR	Agriculture Canada (Liquid Fuels Task)
CONTRACTOR	Acres Consulting Services Ltd. 480 University Avenue Toronto, Ontario M5G 1V2	**SCIENTIFIC AUTHORITY**	E. Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671
PRINCIPAL INVESTIGATOR			

OBJECTIVE

To develop designs, cost estimates & performance estimates for biomass to fuel grade ethanol plants using vapour compression distillation methods as opposed to steam distillation systems.

DESCRIPTION

1. To review available base case plant designs from two US DOE reports and other information available of typical, conventional distillation, grain to ethanol conversion plants at production capacities of approximately 1,000,000 L/y and 45,000,000 L/y respectively.
2. To determine mass and energy balances for the base cases for unit operations and the plants in total, and prepare mass and energy flow diagrams.
3. To derive base case capital cost estimates for the two conventional base case plants and their component operations.
4. To estimate ethanol production costs from base case plant designs to determine sensitivity of production cost to: fuel and power costs, feedstock cost, plant capacity factors, cost of capital and discount rate, and DDGS value.
5. To prepare estimates of capital, operating and total ethanol production costs for plants with different capacities.
6. To prepare detailed engineering designs, drawings, energy and mass blance and operating conditions for the vapour recompression distillation systems suitable for distillation to azeotropic ethanol (and anhydrous ethanol, if appropriate) for the large base case plant.
7. To integrate the vapour compression systems into the two base case processes, making all necessary or desirable modifications to the base case configurations. Determine mass and energy balances and flow diagrams for the two base case plants with vapour compression as described in 2 above.
8. To derive base case capital cost estimates of the two base case plants and their component opertions utilizing vapour compression distillation as described in 3 above.
9. To estimate ethanol production costs from the vapour compression base case plant designs to determine sensitivity of production csosts as described in 4 above.
10. To prepare estimates of capital, operating and ethanol production costs for vapour compression ethanol plants as described in 5 above.
11. Using life cycle cost and sensitivity analysis for the various alternative process variables investigated, comparative screening will give an economic ranking with respect to type of distilling process & plant throughput & will indicate the most economic size range for potential vapour recompression applications.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$73,350			$73,350
1983-84	$ 7,835			$81,185

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 353

TITLE	Study for the Evaluation of a Single Stage Continuous Airlift Fermenter	**PROGRAM IDENTIFICATION**	4.3.8.2 Socio-Economic-Technical Studies/Technology Assess.
CONTRACT #	01843-1-EL10 (OSU81-00512)	**DURATION**	March 1982 - March 1984
		COST	$119,107
CONTRACTOR	Technial University of N.S. P.O. Box 1000 Halifax, Nova Scotia B3A 3X4	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
		SCIENTIFIC AUTHORITY	E. Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Building #94 Central Experimental Farm Ottawa, Ontario K1A 0C6
PRINCIPAL INVESTIGATOR	R.G. Woodside Centre for Energy Studies Tel.: 429-8300 Ext. 113		

OBJECTIVES

The evaluation of an airlift fermenter for the production of alcohol.

DESCRIPTION

The contractor is to make arrangements for delivery of an airlift fermenter, designed and constructed at the University of Manchester, U.K. and the construction of raw material preparation equipment at the Centre for Energy Studies.

Using a single strain of flocculent yeast (and others, if required) the fermentation system will be optimized and evaluated on the following feedstocks: potato culls, potato processing waste, cheese whey, barley, and fodder beet or other comparable energy crop. Cellulose hydrolysate may also be evaluated if time permits and the Scientific Authority can make arrangements for delivery from a separate study.

The contractor is to perform a technical and economic systems analysis and assessment of alcohol fuel production plants for approximately 900,000 L/a and 5,000,000 L/a scale of operation based on the airlift fermenter concept and compare to conventional batch fermentation.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$ 5,000			$ 5,000
1982-83	$ 57,000			$ 62,000
1983-84	$ 57,107			$119,107

REPORTS

STATUS AND COMMENTS

83/05/02

PROJECT DATA SHEET # 239

TITLE	Operating and Developing a Computer Model for Wood to Ethanol	**PROGRAM IDENTIFICATION**	4.3.8.3 Socio-Economic-Technical Studies/Economic Assessment
CONTRACT #	31155-1-2650 (OSX81-00107)	**DURATION**	December 1981 - March 1983
CONTRACTOR	Ontario Research Foundation Sheridan Park Research Community Missisauga, Ontario L5K 1B3	**COST**	$41,780
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	R.J. Laughlin	**SCIENTIFIC AUTHORITY**	R.P. Overend National Research Council Montreal Road Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tele.: (613) 993-1342

OBJECTIVE

In order to assist the NRC in the development of research strategies in biotechnological routes to alcohol, the NRC has obtained an agreement to use for its own purpose a model computer program for use in wood to ethanol technology studies (developed by Imperial Oil Ltd., Toronto, Ontario, & licensed to the National Research Council solely for its own use). The model will be extensively modified to incorporate additional and substitute unit processes and to investigate the effects of various feedstocks and process plant scale.

DESCRIPTION

Task I Perform the following alterations to the model:

1) Change the costing procedure to a supply price estimation method.
2) Modify the feedstock composition so that it can allow for both softwood and hardwood inputs.
3) Replace the existing Imperial with Metric input and output units.
4) Modify the existing unit module to incorporate appropriate heat recovery technologies (e.g. heat exchanger).

Task II Prepare an operator's manual for the Process model.

Task III Using available data on the so-called "Madison" Process with and without pentose recovery such as that contained in the work of E.E. Harris and J.F. Saeman, operate the model as a base case 200 ODt/d of feedstock. Prepare sensitivity analysis for variation in:

1) Scale (50, 100, 500 and 1000 t/d).
2) Identify the most significant variables (e.g. feedstock cost and by-product credits) and evaluate the sensitivity of these.

Task IV Prepare a new model utilizing both the hemicellulose residue as well as stillage as a feedstock to an advanced NRC type anaerobic fixed film digester. Sludge from this module to be treated as either a land amendment or as a protein feed. Methane to be utilized as an in-plant fuel. Test this unit process in the previously described Madison base case described in Task III.

NRC will maintain the model in-house.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$41,780			$41,780

REPORTS

3 reports received. By agreement with the licensor the model and reports will be held confidential until 1986.

STATUS AND COMMENTS

Work is now complete & the contract closed. R.P.O. 83/04/26

PROJECT DATA SHEET # 271

TITLE Comparison Study in Harvesting Forest Biomass as an Alternative Fuel

CONTRACT # K1001-1-22 (OSC81-00262) P-191

CONTRACTOR Bowater Newfoundland Limited
Corner Brook, Newfoundland
A2J 6J4

PRINCIPAL INVESTIGATOR S.R. Murley

PROGRAM IDENTIFICATION 4.3.8.3
Socio-Economic-Technical Studies/Economic Assessment

DURATION 1981-1982

COST $1,072,000

SPONSOR Environment Canada

SCIENTIFIC AUTHORITY R.S. van Nostrand & A.B. Case
Newfoundland Forest Research Centre
Canadian Forestry Service
Box 6028
St. John's, Newfoundland
A1C 5X8

Tele.: (709) 737-4806

OBJECTIVE

To provide a detailed economic and logistic analysis for determining the appropriateness of forest biomass as an alternative fuel.

DESCRIPTION

1. To develop and test practical harvesting (or recovery) and wood-chip production systems for the extraction, processing, and transportation of : (i) hardwood residuals from previously logged cutovers; (ii) wood fuel and pulpwood in an integrated full-tree operation in mixed softwood-hardwood stands; and, (iii) wood residues at roadside and mill-yard slasher-processor sites.

2. To assess the technical and economic feasibility of using forest biomass as an alternative fuel at the Bowater newsprint mill at Corner Brook.

3. To assess the impact of complete tree removal, with emphasis on disturbance to the site, and the silvicultural implications regarding the future crop.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$150,000	*$200,000	$ 15,000	$ 365,000
1982-83	$197,000	$500,000	$ 10,000	$1,072,000
		*Approx.		

REPORTS

Bowater Newfoundland Limited, Harvesting Forest Biomass as an Alternate Fuel. Contractor's Progress Report, 64 p., 1982. (A report on the 1981-82 work)

STATUS AND COMMENTS

Field testing completed. Contractor's final report on 1982-83 work not completed. R.S.VN 83/04/27

PROJECT DATA SHEET # 273

TITLE Evaluation of the Productivity & Costs of Harvesting Wet-Belt Cedar & Hemlock Biomass

CONTRACT # KL017-0-1036 (OSB80-00427)
P-184

CONTRACTOR Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7

PRINCIPAL INVESTIGATOR

PROGRAM IDENTIFICATION 4.3.8.3
Socio-Economic-Technical Studies/Economic Assessment

DURATION April 1, 1981
to March 31, 1983

COST $210,765

SPONSOR Environment Canada

SCIENTIFIC AUTHORITY Glenn H. Manning
Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C.
V8Z 1M5

Tele.: (604) 388-3811

OBJECTIVES

1. Evaluate the productivity and costs of harvesting and processing, by non-conventional means, residual biomass on wet-belt cedar/hemlock sites in interior B.C.
2. Establish the impact of reduced site rehabilitation costs and regeneration costs on the net costs of harvesting residual forest biomass.

DESCRIPTION

1. Trial application of presently available but not necessarily conventional models of yarding and processing equipment best suited to fulfill the stated objectives of the project.
2. The selection of the project site of about 50 ha in size.
3. The sale of salvaged merchantable logs and processed logging residue if feasible.
4. Inventory survey of downed woody material to prescribed standards before and after the wood residue harvest.
5. The collection of representative samples of processed and unprocessed wood residue for laboratory testing and analysis.
6. Research and investigation into site preparation costs, product utilization and marketing chances.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$ 59,000			$ 59,000
1982-83	$149,765		$ 1,000	$210,765

REPORTS

STATUS AND COMMENTS

The contract was amended in June 1982 to determine: 1) the difference in size of biomass that occurs with shearing; 2) the productivity of the biomass shear system. 83/04/27

PROJECT DATA SHEET # 292

TITLE	Develop. of an Integrated Operation for Aspen Wood Products & Energy fm Aspen	**PROGRAM IDENTIFICATION**	4.3.8.3 Socio-Economic-Technical Studies/Economic Assessment
CONTRACT #	KH505-1-0136 (0SG81-00012) P-207	**DURATION**	December 23, 1981 to May 1982
		COST	$129,049
CONTRACTOR	Woodland Resource Services Ltd. 10735 - 180th Street Edmonton, Alberta T5S 1G6	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	W.J. Ondro Northern Forest Research Centre Canadian Forestry Service 5320 - 122 Street Edmonton, Alberta T6H 3S5 Tele.: (403) 435-7210
PRINCIPAL INVESTIGATOR			

OBJECTIVE

DESCRIPTION

1. Organize the field program in cooperation with the forest industry and the Alberta Forest Service and make arrangements for cutting, grading, hauling and processing of the Aspen.
2. Prepare a unit time study on the harvesting and skidding operation and record costs.
3. Prepare a hauling unit time study including loading, hauling, weighing, delivery and unloading at mill. Also prepare a statistical sampling of the biomass of Aspen logging residues.
4. Scale sample loads, calculate volume of wood delivered and establish product recovery by mill.
5. Evaluate mill capacity to produce aspen lumber products and calculate available mill residues.
6. Prepare a market overview by determining end product usage, suitability of logs, product analysis and explore the production of energy from mill wastes for various end uses.
7. Identify future opportunities for wood products and biomass energy.
8. Prepare a study on the capital and operational costs of producing Aspen products and energy and submit a financial analysis and possible alternatives.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$112,968			$112,968
1982-83	$ 15,081		$ 1,000	$129,049

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 207

TITLE	Opportunities for Using Forest Biomass for Energy in Québec	**PROGRAM IDENTIFICATION**	4.3.8.4 Socio-Economic-Technical Studies/Information
CONTRACT #	KL004-0-C019 (OSD80-60) P-157	**DURATION**	2 years
		COST	$38,650
CONTRACTOR	Darveau, Grenier, Lussier et Associés 870, avenue Casot Québec, Québec	**SPONSOR**	Environment Canada
PRINCIPAL INVESTIGATOR	Louis-Jean Lussier Tel.: (418) 683-2385	**SCIENTIFIC AUTHORITY**	G. Frisque Laurentian Forest Research Centre Canadian Forestry Service 1080, route du Vallon Ste-Foy, Québec G1V 4C7 Tel.: (418) 653-2143

OBJECTIVE

To examine critically the existing and planned use of forest biomass for energy within the forest industries.

To identify probable conflicts in biomass use.

DESCRIPTION

Available data on wood consumption for conventional end-uses will be compared to supply data and the new demands to be made if the concept of bioenergy were implemented.

The project will relate only to the specific context of Québec industry and energy demand and supply.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1980-81	$35,000		$ 1,000	$36,000
1982-83	$ 2,000		$ 650	$38,650

REPORTS

LUSSIER L.J., MARANDA J., Perspectives d'utilisation de la biomasse forestière au Québec. ENFOR Project P-157, LAV-X-52, 1982.

LUSSIER L.J., MARANDA J., Prospects for the use of forest biomass in Québec. ENFOR Project P-157, LAV-X-52, 1982. (Available from ENFOR Secretariat and the Energy Library, CISTI)

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 255

TITLE	Comparative Assessment of Forest Biomass Conversion to Energy Forms	**PROGRAM IDENTIFICATION**	4.3.8.4 Socio-Economic-Technical Studies/Information
		DURATION	2 years
CONTRACT #	KN107-1-4416 (OSS81-00228) C-258	**COST**	$798,655
CONTRACTOR	Simons Resource Consultants West Pender Street Vancouver, B.C. V6E 3X4	**SPONSOR**	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	R.P. Overend National Research Council Building M-55 Room 381 Ottawa, Ontario K1A OR6 Tel.: (613) 993-1342

OBJECTIVE

The objective of this requirement is to pull together conversion process data into a single source. Both existing and near term technology for the conversion of forest biomass into usable forms of energy will be covered. This report will assist government and industry in making decisions regarding the provision of facilities generating alternate forms of energy.
Terms of Reference: Utilizing literature surveys, direct contacts and other available means, the contractor shall prepare a critical evaluation of the several unit processes that are the basis of complete forest biomass to fuel production conversion plants.
Examples of unit processes are: comminution, drying, solid fuel preparation, combusters, low joule gas (LJV), medium joule gas (MJV), gas clean up, synthetic gas production, etc.
The evaluations shall reflect the Energy from Forest (ENFOR) Program results and data plus the experience of other countries. The unit processes are to be assembled into complete systems such as production of process steam, application of hot gases and/or LJV in kiln drying, lime kilns and chemical processes.
Utilization of synthetic gas to produce methanol and ammonia, and ethanol production by fermentaiton, are to be considered.

DESCRIPTION

The work will be reported in the form of a series of Data volumes using the unit process concept. Costing will generally be developed as a parametric description enabling users to identify appropriate size ranges and then to develop their own costing to curve.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$438,350			$438,350
1983-84	$360,305			$798,655

REPORTS

Phase I - Commercial and near commercial technologies will be published as a series of volumes during the summer of 1983.

STATUS AND COMMENTS

Work in progress - very slightly delayed. R.P.O. 83/04/26

PROJECT DATA SHEET # 300

TITLE	Review of the ENFOR Production Program	**PROGRAM IDENTIFICATION**	4.3.8.4 Socio-Economic-Technical Studies/Information
CONTRACT #	KN107-2-4355 (OSS82-00117) P-245	**DURATION**	October 25, 1982 to March 31, 1983
CONTRACTOR	Dendron Resource Surveys Ltd. P.O. Box 6493 Postal Station 'J' Ottawa, Ontario K2A 3Y6	**COST**	$42,096
		SPONSOR	Environment Canada
		SCIENTIFIC AUTHORITY	Grant Hawes Canadian Forestry Service Department of the Environment Place Vincent Massey Bldg 19th Floor Hull, Québec K1A 1G5 Tel.: (819) 994-1879
PRINCIPAL INVESTIGATOR			

OBJECTIVES

1. To review and assess the accomplishments of the ENFOR Production Program in light of program and broader government objectives.
2. To identify problem areas and research topics warranting further investigation, and to recommend program strategies for responding to these needs.
3. To prepare an annotated bibliography and digest of ENFOR Production Program reports (including those contractors' reports not yet published).

DESCRIPTION

The contractor will meet with representatives of each participating CFS establishment to familiarize himself with that establishment's ENFOR-related program (in-house as well as contracted work), and to obtain perceptions of remaining requirements and priorities for forest biomass production research. Wherever feasible, these meetings should be augmented by discussions with appropriate industrial and provincial forestry and energy officials.

ENFOR Production Program documents, final reports of all completed Production projects, and interim reports of current projects will be reviewed and annotated. Other key reports from the literature will also be reviewed to establish the socio-economic and technological context of the program.

Based on the interviews and reading outlined above, the contractor will prepare 2 reports. the first will address objectives 1 and 2; that is, it will be a critical assessment of the accomplishments of the Production Program, will identify problem areas and research topics warranting further investigation, and will recommend program strategies. The second report will be an annotated bibliography and digest of Production Program reports in satisfaction of objective 3.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$42,096			$42,096

REPORTS

STATUS AND COMMENTS

83/04/27

BIOMASS MATERIALS HANDLING, TRANSPORTATION AND PRE-TREATMENT

General

Materials Handling

Transportation

Pre-treatment

PROJECT DATA SHEET # 154

TITLE	Bin and Silo Design for Biomass Materials
CONTRACT #	KL229-0-4120 (OSS80-43) C130
CONTRACTOR	B.C. Research 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2
PRINCIPAL INVESTIGATOR	N. Bundalli
PROGRAM IDENTIFICATION	4.3.9.2 Biomass Materials Handling, Transportation & Pretreatment/Materials Handling
DURATION	4 years
COST	$425,468
SPONSOR	Environment Canada
SCIENTIFIC AUTHORITY	R.J. Neale Vincent Massey Building Hull, Que. K1A 0E7 (613) 997-1682
TECHNICAL LIAISON OFFICER	Dr. J.F.G. Mackay Forintek Canada Corporation Western Laboratory 6620 NW Marine Drive Vancouver, B.C. V6T 1X2 (604) 224-3221

OBJECTIVE

1. To design and construct a shear testing apparatus suitable for biomass materials in order to obtain data necessary for better design of bins and silos used for storing such materials.
2. To test different types of biomass materials under varying conditions so as to make suitable recommendations on bin and silo design as well as material conditioning (where appropriate) to achieve uninterrupted and uniform discharge.
3. To identify factors which contribute to poor flow properties.

DESCRIPTION

A shear testing apparatus with a large enough cell to hold sufficient quantity of a woodwaste material will be designed in detail.

The apparatus will have some of the features of the Jenike Tester but with a cell diameter of 76.2 cm. Shearing will be carried out by pulling the top half of the cell by means of a steel cable-attached to the cell, preferably at a constant rate to achieve a steady strain rate. The stress required to shear the material will be measured by a suitable tensile transducer connected to the steel cable.

For wall friction tests, the bottom cell ring will be replaced by a plate of the bin wall material to be tested. Several plates will be made up of different construction materials, some with special linings used to reduce wall friction.

Several extra cells will be made up to carry out time consolidation tests to determine the effect on the flow properties of storing woodwaste materials in bins over periods of time without discharging. Since individual components of the apparatus are likely to be of considerable weight and size, adequate provision will be made for lifting and manoeuvring the items with ease.

Following construction of the shear testing apparatus, some trial tests will be carried out to check the equipment for proper functioning. Any necessary modifications will be done.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1980-81	$115,100			$115,100
1981-82	$123,467			$238,567
1982-83	$140,506			$379,073
1983-84	$ 46,395			$425,468

REPORTS

BUNDALLI N., MARTINEZ O., B.C. Research, Bin and Silo Design for Biomass Materials, Vancouver, B.C., July 1982. ENFOR Project C-130. (Available from ENFOR Secretariat)

STATUS AND COMMENTS

The contract is to include an examination of the effects of cold weather conditions and also study the storage of peat.

83/04/14

PROJECT DATA SHEET # 181

TITLE	Fuel Value of Stored Forest/ Mill Residues	**PROGRAM IDENTIFICATION**	4.3.9.2 Biomass Materials Handling, Transportation and Pretreatment/Materials Handling
CONTRACT #	KL229-1-4106 (OSS81-00035) C-220	**DURATION**	May 1981 - May 1982
CONTRACTOR	Forintek Canada Corporation Eastern Laboratory 800 Montreal Road Ottawa, Ont. K1G 3Z5	**COST**	$36,579
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	H. Unligil	**SCIENTIFIC AUTHORITY**	R.P. Overend National Research Council Division of Energy R&D Room 381, Bldg. M-55 Ottawa, Ontario K1A 0R6 Tel.: (613) 993-1342

OBJECTIVE

1. To conduct a survey of the literature on: conditions existing in outside piles of woody particles (wood chips, forest and mill residues); factors involved in the decrease of calorific value of wood; and, measures to prevent storage losses.
2. To discuss recent developments in the use of forest biomass as an energy source, and their possible impact on storage practices.
3. Indicate areas to which research should be directed.

DESCRIPTION

Literature survey.

A. An introduction to provide information on the fuel value of wood and methods of measurement of the fuel value; the deterioration of wood generally; the current handling and storage practices, volume, and economic significance of the forest biomass.

B. Moisture content of stored piles of woody particles: the sources of moisture, its significance in deterioration and loss of fuel value of wood.

C. Heat generation phenomenon: its causes; the factors influencing its development; and its consequences.

D. Deterioration of wood resulting in a loss in calorific value: the rate of deterioration. Microbial deterioration will receive special attention. Weight loss changes in chemical composition and their effect on fuel value.

E. Methods of reducing storage losses; physical methods; chemicals; biological protection.

F. Environment consequences of fuelwood storage and chemical and biological treatments.

G. Prospects and recent developments in use of biomass materials as energy source and their implications to the storage practice of woody particles.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$31,135			$31,135
1982-83	$ 5,444			$36,579

REPORTS

Published by ENFOR as C-220.

STATUS AND COMMENTS

Completed. The work summarized the current status of hog and chip fuel storage and highlighted concerns and identified a work program for possible future funding. R.P.O.

83/04/26

PROJECT DATA SHEET # 193

TITLE	A Study of the Forces Exerted by Hog Fuel Piles on Restraining Structures.	**PROGRAM IDENTIFICATION**	4.3.9.2 Biomass Materials Handlings, Transportation and Pretreatment/Materials Handling
CONTRACT #	KL229-1-4217(0SS81-00096) C-254	**DURATION**	September 1981 - July 1982
CONTRACTOR	B.H. Levelton & Assoc. Ltd., 8805 Osler Street, Vancouver, B.C. V6P 4G1	**COST**	$88,000
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR		**SCIENTIFIC AUTHORITY**	R.J. Neale Place Vincent Massey Hull, Quebec. K1A OE7 (613) 997-1682
		TECHNICAL LIAISON OFFICER	J.F.G. MacKay Forintek Canada Corporation Western Laboratory 6620 N.W. Marine Drive Vancouver, B.C. V6T 1X2

OBJECTIVE

To undertake field measurements to develop basic data on the lateral forces exerted by hog fuel piles (work will be done at the realscale under plant conditions so that realistic information will be obtained).

1. as a function of pile depth
2. as affected by vehicular traffic on the pile
3. as a function of moisture
4. variation with time
5. as affected by loading or unloading of the pile
6. to produce data for engineers to provide a basis for designing fuel storage areas.

DESCRIPTION

1. To conduct a survey of the potential mill sites for the project in the Vancouver area by H.A. Simons Int. Ltd.
2. To conduct a survey of instrumentation to identify what types are best suited to the requirements.
3. Pressure sensors and transducers will be selected for point force measurements and gross force.
4. Height of fuel pile immediately above the sensor and at a distance of 10 ft. from the wall will be recorded by mechanical sounder.
5. Force on the wall will be measured away from the corners of the bin on a vertical wall approximately 2 ft. above the floor. A gross force measurement and a point force measurement will be taken at the same level. One point force measurement will be taken at some level higher above the floor.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$60,000			$60,000
1982-83	$28,000			$88,000

REPORTS

EDWARDS W.C. & TAM P., B.H. Levelton & Associates Ltd., Forces Exerted on Restraining Structures by Hog Fuel Piles. ENFOR Project C-254, September 1982. (Final report)

STATUS AND COMMENTS On the basis of work completed by August 1981 two sites were selected for data collection. Phase one of the study was at Crown Zellerbach, Coast Wood Products Division of Coquitlam, B.C.
Phase two was at Canadian Forest Products of New Westminster, B.C.
Project Completed.

83/04/26

PROJECT DATA SHEET # 308

TITLE	Development of a Feed Mechanism for Straw Burners	**PROGRAM IDENTIFICATION**	4.3.9.2 Biomass Materials Handling, Transportation and Pre-Treatment/Materials Handling
CONTRACT #	01843-1-ER12 (OSZ81-00130)	**DURATION**	February 10, 1982 to March 31, 1984
CONTRACTOR	Biomass Combustion Limited Canning, Nova Scotia B0P 1H0	**COST**	$75,000
		SPONSOR	Agriculture Canada
PRINCIPAL INVESTIGATOR	J. Peill	**SCIENTIFIC AUTHORITY**	D. Marshall Engineering and Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671

OBJECTIVE

DESCRIPTION

Evaluation of engineering alternatives

A. Bale Dissolver Options

1. Loose flail type
2. Fixed flail type
3. Auger with cutting edge type
4. Rotating disc type
5. Gang saw type
6. Multiple circular saw type
7. Tub grinder type

B. Stoker Options

1. Single auger and best configuration
2. Double auger and best configuration
3. Hydraulic ram type
4. Mechanical ram type

C. Back Burn Preventer

1. For single auger-water or mechanical plus suitable sensing device
2. For double auger-water or mechanical plus suitable sensing device
3. For ram types-water or mechanical plus suitable sensing device

D. Select components, complete fabrication drawings of chosen design and fabricate, install and monitor operation.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$15,227			$15,227
1982-83	$56,009			$71,236
1983-84	$ 3,764			$75,000

REPORTS

STATUS AND COMMENTS

83/04/27

PROJECT DATA SHEET # 324

TITLE	Development of a Dense Phase Pneumatic Conveying System for Biomass Materials	**PROGRAM IDENTIFICATION**	4.3.9.2 Biomass Materials Handling, Transportation & Pre-Treatment/Materials Handling
CONTRACT #	KN107-2-4081 (0SS82-00033) C-273	**DURATION**	May 20, 1982 to October 15, 1983
CONTRACTOR	B.C. Research 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	**COST**	$219,960
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	Nazmir Bundalli Tel.: (604) 224-4331	**SCIENTIFIC AUTHORITY**	Mr. R.J. Neale Canadian Forestry Service Place Vincent Massey Bldg. 20th Floor Hull, Québec K1A 1G5
		TECHNICAL LIAISON OFFICER	Mr. J.F.G. Mackay Forintek Canada Corporation Western Laboratory 6620 N.W. Marine Drive Vancouver, B.C. V6T 1X2

OBJECTIVE

To develop a pneumatic conveying system for hog fuel and other biomass materials which will have considerably lower air requirements and would operate at lower conveying velocities.

DESCRIPTION

A pilot scale pneumatic conveying system will be designed by B.C. Research and ACO Sales and assembled at B.C. Research. The system will be of the "Pulse Flow" type where the material is separated into plugs by air cushions. Such a system has been developed in the U.K. for domestic refuse and operates at much lower air velocities.

Development work will be carried out on the pilot scale pneumatic system. Attempts will be made to feed and convey material in "plug" form. Initial tests wil be on a short length of pipe which will be progressively increased. This system will be optimized in terms of plug lengths, air volume and pressure. The pilot scale system will be well instrumented in order to obtain data necessary to scale up to a commercial size system.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$110,000			$110,000
1983-84	$109,960			$219,960

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 180

TITLE	To Perform a Study of Hog Fuel Drying Using Vapour Recompression	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Transportation & Pretreatment/Pretreatment.
CONTRACT #	KL229-1-4120 C-214	**DURATION**	May 1981 - March 1983
CONTRACTOR	Pulp and Paper Research Inst. 570 St. John's Blvd. Pointe Claire, Quebec. H9R 3J9	**COST**	$294,006
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	W.R. Aird	**SCIENTIFIC AUTHORITY**	R.J. Neale Place Vincent Massey Hull, Quebec. K1A 0E7 (613) 997-1682
		TECHNICAL LIAISON OFFICER:	D.R. Huffman Forintek Canada Corporation Eastern Laboratory 800 Montreal Road Ottawa, Ontario. K1G 3Z5 (613) 744-0963

OBJECTIVE

To evaluate experimentally the pertinent parameters of two conceptual processes of drying hog fuel, and to assess the feasibility of applying vapour recompression to these processes.

DESCRIPTION

A. The design and construction of a laboratory-scale dryer consisting of an internally heated vessel, steam generator, vapour condenser and appropriate controls and instrumentation. The vessel will be operated batchwise, and drying rates determined from the flow rates of condensed vapours.

B. Testing of the dryer, with hog fuel from different sources, to determine the drying of hog fuel as a function of:
   1. steam condensing temperature
   2. size of hog fuel praticles (including bark produced in PAPRICAN's chip debarking process)
   3. the moisture content of hog fuel.

C. Experimental system will be tested with crude tall oil as heating medium followed by determination of the hog fuel drying rates as a function of the variables in B. the degree of oil entrainment with wood and losses due to evaporation will also be measured. The pollution characteristics of the condensates will be determined on some selected samples.

D. Tests will be done to determine feasibility and product characteristics of prepared densified fuel from the product derived in C.

E. A technical and economic assessment and comparison of the two vapour recompression drying systems based on the information gained in B, C, D. A preliminary design of a continous pilot-scale dryer.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$134,806			$134,806
1982-83	$159,200			$294,006

REPORTS

SAYEGH N.N., AZARNIOUCH K., PPRIC, Hog Fuel Drying Using Vapour Recompression (Phase I). Pointe Claire, Québec, ENFOR Project C-214.

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 183

TITLE	A study of the pretreatment preparation of forest biomass as feedstock for bioconversion processes	PROGRAM IDENTIFICATION	4.3.9.4 Biomass Materials Handling, Transportation and Pretreatment/Pretreatment
		DURATION	May 1981-April 1983
CONTRACT #	KL229-1-4121 (OSS81-00026) C-222	COST	$118,860
CONTRACTOR	University of Waterloo Waterloo, Ontario N2L 3G1	SPONSOR	Environment Canada
		SCIENTIFIC AUTHORITY	S.M. Martin Division of Biological Sciences National Research Council Ottawa, Ontario K1A 0R6
PRINCIPAL INVESTIGATOR	D. Murray Moo-Young		

OBJECTIVE

To develop and test a novel process whereby forest biomass (as wood, pulpmill sludge) is converted by chemical hydrolysis, enhanced by gamma irradiation or microwaves, into a liquid product which is suitable as feedstock for known conversion technologies in the production of industrial chemical and fuels. The aim is economic production of feedstocks.

DESCRIPTION

The project will cover two main areas of study.

1. Experimental development of the pretreatment method for optimal depolymerization, sugar yields and conversion rates. The effects of irradiation dosage, particle size and chemical strength will be examined. The prepared feedstocks will be tested in actual bioconversion processes to gain insight in its suitability.

2. Economic evaluation of the method as it compares to existing feedstock availability and other pretreatment methods for a range of conversion technologies. Computer programs will be developed for various sensitivity analyses.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$58,000			$ 58,000
1982-83	$55,570			$113,570
1983-84	$ 5,290			$118,860

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 192

TITLE	Design, fabrication & testing of a prototype log splitter.	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Transportaiton and Pretreatment/Pretreatment
CONTRACT #	81-82 KL229-1-4162(0SS81-00085) P-216 82-83 KH405-2-0041(0SS82-00045)	**DURATION**	July 1981 - March 1983
		COST	$284,920
CONTRACTOR	Forest Engineering Research Inst. of Canada 143 Place Frontenac Pointe Claire, Québec. H9R 4Z7	**SPONSOR**	Environment Canada
		SCIENTIFIC AUTHORITY	B.J. Sutherland Great Lakes Forest Research Centre 1189 Queen Street Sault-Ste-Marie, Ontario
RINCIPAL INVESTIGATOR	Denis Brière		

OBJECTIVE

To design, build and test a roll splitter capable of continuously splitting woody biomass up to 30 cm in diameter and simultaneously reducing its moisture content.

DESCRIPTION

Phase I

1. To develop and fabricate a portable roll splitter capable of continuously splitting wood parallel to the grain, crushing its structural integrity and reducing its moisture content.

2. To field test the experimental prototype and measure its energy consumption, hydraulic forces, productivity, and general performance.

Phase II

1. Demonstrate that large splinters produced by existing roll splitter can be further reduced through crushing by a set of large diameter (50-60 cm) smooth rolls.

2. Demonstrate that the splintering, crushing and dewatering operations can be combined into a single machine using two pairs of rolls in series; the first, with axe heads, splintering the larger material, and the second smooth rolls for crushing and dewatering.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	IN-HOUSE	CUMULATIVE TOTAL
1981-82	$119,500			$119,500
1982-83	$163,420		$ 2,000	$284,920

REPORTS

STATUS AND COMMENTS

Sub-contract to K.C. Jones and Associates Limited.

83/04/26

PROJECT DATA SHEET # 196

TITLE	Pretreatment Methods for Enhancing Conversion of Lignocellulosic Material to Liquid Fuel	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Transportation & Pre-treatment/Pre-treatment
		DURATION	July 1982 - July 1983
CONTRACT #	KN107-2-4216 (0SS82-00061) C-299	**COST**	$106,462
		SPONSOR	Environment Canada
CONTRACTOR	FORINTEK Canada Corp. Eastern Laboratory 800 Montreal Road Ottawa, Ontario K1G 3Z5	**SCIENTIFIC AUTHORITY**	wm Lyse Morisset National Research Council Building M-55 Room 381 Ottawa, Ontario K1A 0R6 Tel.: (613) 993-1542
PRINCIPAL INVESTIGATOR			

OBJECTIVE

To develop pretreatment methods for the enhanced conversion of lignocellulosic material to liquid fuels.

DESCRIPTION

1. To instrument the Forintek bench-scale steam explosion equipment to determine process parameters for reliable and reproducible enzyme-fermentable products.
2. To determine the feasibility of converting wood into three chemical streams (hemicellulose, lignin and cellulose) by means of treatment with steam combined with additional low-cost treatments.
3. To establish the chemical nature of the inhibitors and find, if possible, a low-cost treatment to remove or denature them.
4. To determine whether it is better to separate the three chemical streams before enzymatic hydrolysis, or to separate the lignin-cellulose stream after enzymatic hydrolysis.
5. To carry out an Electron Microscopy study of the steam-treated wood and of the fractions derived from it, to determine whether or not the location or distribution of the lignin on the cellulose is more important than is the amount or nature of the lignin present, and to clarify the role of surface area in these materials.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 50,000			$ 50,000
1983-84	$ 56,462			$106,462

REPORTS

STATUS AND COMMENTS

83/04/14

PROJECT DATA SHEET # 215

TITLE	Assessment of Wet Oxidation of Agricultural Residues to Form Fermentation Substrates	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materia Handling, Transportation and Pretreatment/Pretreatment
CONTRACT #	34SZ.01843-0-B103 (0SZ81-43)	**DURATION**	August 1981 - Se ber 1983
CONTRACTOR	Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario	**COST**	$120,000
		SPONSOR	Agriculture Canada
PRINCIPAL INVESTIGATOR	Herb Robey	**SCIENTIFIC AUTHORITY**	E. Manolakis Engineering & Statistical Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (6) 671

OBJECTIVE

The overall objective of the project is to develop and test a system that converts corn stover to a fermentable substrate by using a combination of acid hydrolysis reactors and wet oxidation of residual lignin and swine manure or stover/manure mixtures. The system will produce pentose and hexose sugar streams of high theoretical yield (60% or more) that are sterile and can be fermented to fuel ethanol in particular or others such as acetone, and butanol. The system is intended to generate most of its own requirements for acid, energy (steam), and essential nutrients for fermentation.

DESCRIPTION

Phase 1 (The Hydrolysis System)

The contractor will perform preliminary investigations of a "hydrolysis system" using separate reactors for acetic acid and steam hydrolysis of corn stover which will yield pentose and hexose sugar streams. Lignin residue from the cellulose hydrolysis reactor will be wet oxidized using the WETOX reactor to optimize steam and acetic acid production, reaction kinetics and process conditions relative to the requirements of the hemicellulose and cellulose hydrolysis reactors. The experiments will be carried out in a batch/bench scale configuration where system integration is simulated only. For each promising sugar stream produced in the experiments, studies to ensure that the sugar streams are fermentable will be conducted at the flask scale (anaerobically, where practical). (Note: Fermentability studies refer primarily to hexose sugar streams). Preliminary investigations only of fermenting pentose sugar streams to fuel ethanol will be conducted.

Phase 2 (The Manure Treatment System)

The contractor will perform basic research studies on: 1) wet oxidation of swine manure to supply nutrients (for fermentation) and/or steam and acid; 2) wet oxidation of manure/lignin mixtures to supply nutrients and/or steam and/or acid and; 3) oxidative hydrolysis of stover/manure mixtures to supply nutrients, steam, acid and/or fermentable carbohydrates. Products from these experiments (e.g. steam, acid, nutrients, fermentable carbohydrates) will be studied with respect to fermentability in experiments using sugar streams produced in Phase 1 experiments and on products derived solely from wet oxidation of manure or stover/manure mixtures.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$25,000			$ 25,000
1982-83	$80,000			$105,000
1983-84	$15,000			$120,000

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 234

TITLE	Microbial Fractionation of Native Biomass to Lignin, Cellulose and Hemicellulose	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Transportation & Pretreatment/Pretreatment
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	Queen's University Department of Chemical Engineering Kingston, Ontario K7L 3N6	**COST**	$87,000
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	D.H. Bone	**SCIENTIFIC AUTHORITY**	n/a

OBJECTIVE

To develop a fermentation process which will convert wood, bark, straw and other native lignocellulosics (LC) into free lignin, cellulose and hemicellulose using lignolytic fungi. Lignin will be further processed into aromatics and phenols by microbes. Cellulose and hemicellulose will be available in an easily utilizable form for conversion to sugars, which can then be used as a substrate for the production of liquid fuels (e.g. ethanol). Two bioreactors will be used: a recirculating tower bioreactor and a fluidized bed reactor. The microbial conversion of LC to lignin and polysaccharides will be optimized for minimum energy use and economics.

DESCRIPTION

1. Using white-rot fungi to break open the lignin-cellulose-hemicellulose complex with minimal degradation of the polysaccharides, and to utilize a range of native LC including woodchips, bark and straw.
2. To compare two reactor systems (a) continuously fed fluidized bed reactor (FBR) (b) recirculating tower bioreactor (RTB).
3. To optimize these two reactors for efficient production of free lignin, cellulose and hemicellulose for their further conversion to liquid fuels and chemicals.
4. To select strains of microbes which will be able to co-metabolize lignin to aromatics and phenols.
5. To supply laboratories, working on energy from biomass, with cellulose and hemicellulose derived from LC.
6. To conduct a techno-economic evaluation of the conversion systems based on laboratory experience, and the persuasion of chemical companies to investigate the developed process.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$38,000			$38,000
1982-83	$24,000			$62,000
1983-84	$25,000			$87,000

REPORTS

STATUS AND COMMENTS

Working in collaboration with A.J. Daugulis.

83/03/02

PROJECT DATA SHEET # 238

TITLE	Saccharification of Biomass by Reduced Pressure Pyrolysis Followed by Hydrolysis	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Material Handling, Transportation & Pre-treatment/Pre-treatment
CONTRACT #	Strategic Grant	**DURATION**	3 years
CONTRACTOR	Département de génie chimique Université de Sherbrooke Sherbrooke, Québec	**COST**	$152,856
		SPONSOR	Natural Sciences and Engineering Research Council
PRINCIPAL INVESTIGATOR	C. Roy	**SCIENTIFIC AUTHORITY**	n/a

OBJECTIVE

To undertake pyrolytic saccharification of wood for the production of ethanol.

U.S. studies on pure cellulose have indicated that pyrolysis under reduced pressure produces material that is readily hydrolyzable. It is proposed to investigate the conversion of different lignocellulosics.

DESCRIPTION

The overall approach will be the pyrolytic conversion of different lignocellulosics under reduced pressure. The pyroligneous material will at the same time be characterized and acid hydrolysed to determine its suitability as a feedstock for ethanol production.

Short Term: To produce samples of pyroligneous material from diverse lignocellulosics (hardwood, soft wood, wheat straw, oat straw, corn stover, bark) in order to treat them by acid hydrolysis (batch). Catalysts will be tested to increase yields or to suitably modify the pyroligneous material.
To develop analytical techniques for the identification and quantification of the sugars.

Long Term: If the batch hydrolysis tests prove promising further development will be undertaken. To determine the fermentability of the hydrolysate and to investigate any microbial inhibitors in the hydrolysate. If inhibitors are present the sugars would be isolated or purified. Preliminary fermentation would be carried out by either conventional yeast or by bacteria adapted to pentoses and hexoses.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR	EQUIPMENT	CUMULATIVE TOTAL
1981-82	$36,000		$ 8,500	$ 44,500
1982-83	$40,356		$32,000	$116,856
1983-84	$36,000			$152,856

REPORTS

ROY C., DE CAUMIA B., PLANTE P., Production of Liquids from Biomass by Vacuum Pyrolysis - Development of Data Base for Continuous Process. Institute of Gas Technology. Seventh Annual Meeting on Energy from Biomass and Wastes. Lake Buena Vista, Florida, January 24-28, 1983.

ROY C., DE CAUMIA B, BROUILLARD D, MÉNARD H., The Pyrolysis Under Vacuum of Aspen Poplar. Fundamentals of Thermochemical Biomass Conversion: an International Conference. Estes Park, Colorado. October 18-22, 1982.

ROY C., Possibilités de la pyrolyse à pression réduite pour la production de substances liquides à partir de la biomasse. Compte-rendu du Quatrième Séminaire R&D Bioénergétique. Winnipeg, Manitoba. 29-31 mars, 1982. (27-30).

STATUS AND COMMENTS

Working in collaboration with H. Ménard, E. Chornet and, B.P. Cayrol. C.R. 83/04/26

PROJECT DATA SHEET # 241

TITLE	Evaluation of a One Stage Continuous Acid Hydrolysis Process for Conversion of Agricultural Materials into Sugars	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Transportation & Pretreatment/Pretreatment
		DURATION	November 1981 - March 1983
CONTRACT #	01843-1-EL04 (OSZ81-00098)	**COST**	$56,314
CONTRACTOR	Stake Technology Ltd. 220 Wyecroft Road Oakville, Ontario L6K 3V1	**SPONSOR**	Agriculture Canada (Liquid Fuels Task)
		SCIENTIFIC AUTHORITY	E. Manolakis Engineering & Statistical Research Institute Building 94 Agriculture Canada Ottawa, Ontario K1A 0C6
PRINCIPAL INVESTIGATOR			

OBJECTIVE

The overall objective of the project is to perform exploratory tests on the patented Stake Technology autohydrolysis reactor using combined steam treatment and a hydrogen ion source such as the infusion of SO2 on a variety of agricultural materials. Tested for each combination of residence time, temperature and hydrogen ion concentration and process configuration (i.e. single pass or double pass, etc.) the production of fermentable sugar is to be optimized for the production of fuel ethanol. The exploratory nature of the project is to test the above concept so that a decision can be made regarding carry-on studies to establish a detailed technical and economic model.

DESCRIPTION

The contractor will perform preliminary experiments on a batch/bench scale autohydrolysis reactor (approx. 50 g samples) to determine optimum reaction kinetics and process conditions using steam treatment and a hydrogen ion source (e.g. infusion of SO_2 gas or others) for the maximum or optimum conversion of designated feedstocks to fermentable monosaccharides without subsequent enzyme hydrolysis. Designated feedstocks are to include corn grain, corn stover alone, corn cobs, barley grain and barley straw. Sugars from the liquid stream only will be analyzed qualitatively and quantitatively to determine optimum and maximum production of fermentable sugar relative to process conditions and flow configuration. Fermentability studies will be conducted on promising sugar hydrolysates (Note: Fermentability studies refer to preliminary investigations only in a flask or test tube scale to determine if the sugar streams are fermentable (anaerobically, if practical)). The contractor will observe the impact of autohydrolysis on potential protein and oil recovery/degradation on corn and barley grain feedstocks.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$12,814			$12,814
1982-83	$43,500			$56,314

REPORTS

STATUS AND COMMENTS

83/04/26

PROJECT DATA SHEET # 320

TITLE	Use of Extrusion in the Conversion of Agricultural Biomass to Fuel Alcohol	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Transportation & Pre-treatment/Pre-treatment
CONTRACT #	01916-2-EL17 (1SZ82-00058)	**DURATION**	July 22, 1982 to August 1, 1983
CONTRACTOR	Weston Research Centre 1047 Yonge Street Toronto, Ontario M4W 2L3	**COST**	$68,000
		SPONSOR	Agriculture Canada (Liquid Fuels Task)
		SCIENTIFIC AUTHORITY	E. Manolakis Engineering & Statistical Research Institute Research Branch Agriculture Canada Ottawa, Ontario K1A 0C6 Tel.: (613) 995-9671
PRINCIPAL INVESTIGATOR	Ray Edamura Tel.: (416) 922-5100		

OBJECTIVE

To develop and assess the economic feasibility of the 2-stage extruder process, combined with microbial fermentation, for the rapid conversion of agricultural biomass to fuel grade ethanol.

DESCRIPTION

1. To hydrolyse agricultural feedstocks (corn stover, wheat straw, alfalfa) to fermentable sugars using a two stage extrusion process. The proces will be optimized for maximum production of pentose and hexose sugars. Extruded material from each stage will be analytically monitored for moisture, lignin, sugar content (yield and concentration) and ash. Extruded material from the first stage will be monitored for enzyme and acid digestibility. Operating parameters to be varied in each stage will include temperature, pressure, residence time and catalyst concentration.
2. To assess the fermentability of selected samples from the process streams of each stage.
3. To determine the energy inputs and mass balances of the most promising process configurations and compare to other methods of pretreatment/hydrolysis such as steam explosion, ball milling, acid and enzyme hydrolysis.
4. To perform an economic prefeasibility evaluation of the use of extrusion to pretreat/hydrolyse the agricultural feedstocks tested.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$68,000			$68,000

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 327

TITLE	Biomass Feedstocks from Poplar Wood using Supercritical Fluids	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Transportation & Pre-treatment/Pre-treatment
CONTRACT #	KN107-2-4110 (OSS82-00026) C-295	**DURATION**	May 19, '82 - March 31, '83
CONTRACTOR	B.C. Research 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	**COST**	$77,464
		SPONSOR	Environment Canada
PRINCIPAL INVESTIGATOR	E. McDonald John Howard Tel.: (604) 224-4331	**SCIENTIFIC AUTHORITY**	R.J. Neale Canadian Forestry Service Plance Vincent Massey Bldg. 19th Floor Hull, Québec K1A 1G5 Tel.: (819) 997-3409
		TECHNICAL LIAISON OFFICER	J.F.G. MacKay Forintek Canada Corporation Western Laboratory 6620 N.W. Marine Drive Vancouver, B.C. V6T 1X2 Tel.: (604) 224-3221

OBJECTIVE

To enhance the digestibility of wood for ruminant animals by using supercritical fluids to modify cell walls and disrupt cellulose-lignin bonds.

DESCRIPTION

Poplar will be treated with supercritical fluids including carbon dioxide and possibly ammonia. Pressures in the treatment chamber will be changed rapidly to cause maximum disruption to chemical bonds and the physical structure of wood. Test will be run on the treated wood to determine digestibility improvements. An economic assessment will be made of the process developed.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$77,464			$77,464

REPORTS

STATUS AND COMMENTS

83/04/29

PROJECT DATA SHEET # 347

TITLE	Preparation of Wood for Combustion	**PROGRAM IDENTIFICATION**	4.3.9.4 Biomass Materials Handling, Pre-treatment/Pre-treatment
		DURATION	July 1982 - May 1983
CONTRACT #	CEA 6297		
CONTRACTOR	Sandwell Suite 601 1550 Alberni Street Vancouver, B.C. V6G 1A4	**COST**	$50,980
		SPONSOR	Canadian Electrical Association
		TECHNICAL ADVISORS	
PRINCIPAL INVESTIGATOR	Colin MacCallum		

OBJECTIVES

The CEA requested Sandwell to study the use of wood particles as fuel in conventional utility boilers, for the production of electricity. In the first part of the study, considertion was given to the possible advantages of prior separation of the wood into lignin and wood fibre. After a thorough assessment, there did not appear to be any incentive for separating the lignin and wood fibre. At a meeting with the CEA technical advisors, it was agreed that the remainder of the project would focus on factors pertinent to the preparation of wood for combustion in conventional utility boilers.

DESCRIPTION

1. When outstanding information is obtained from suppliers, complete the report sections on (a) the review of equipment for size reduction of wood, (b) the effect of particle size and moisture content on burnout time and (c) the effect of wood co-firing on the emission of SO_2 and SO_3 from the combustion of fossil fuels.
2. Prepare a draft report section on the drying of wood waste.
3. Assess the optimum feed for various existing conventional utility boilers. Superficially, it appears that pulverized firing would be the only feasible alternative.
4. Review the burner requirements for firing pulverized hog fuel.
5. Develop capital and operating costs for systems to prepare wood fuel for feasible firing methods.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1982-83	$ 50,980			$ 50,980

REPORTS

STATUS AND COMMENTS

Since it is not attractive to separate lignin from wood fibre prior to combustion, the balance of the project is focussing on the technical factors and associated economics of preparing wood for combustion in conventional utility boilers. Although we are waiting for some supplementary information, report sections have been prepared on (a) the review of equipment for size reduction of wood, (b) the effect of particle size and moisture content on combustion characteristics and (c) the effect of wood co-firing on the emission of SO_2 and SO_3 from the combustion of fossil fuels. After other appropriate technical factors have been addressed and the feasible firing methods have been identified, capital and operating costs for systems to prepare wood fuel will be developed. Final report is in preparation.

83/04/29

BIOENERGY PROJECT MANAGEMENT

PROJECT DATA SHEET # 102

TITLE	Project Management in support of ENFOR	**PROGRAM IDENTIFICATION**	4.3.10 Bioenergy/Project Management
CONTRACT #	Separate contracts signed each year (E-1)	**DURATION**	1 April 1979 to 31 March 1983
CONTRACTOR	Forintek Canada Corporation	**COST**	$564,835
PRINCIPAL INVESTIGATOR	D.R. Huffman Eastern Laboratory 800 Montreal Road Ottawa, Ontario K1G 3Z5 J.F.G. MacKay Western Laboratory 6620 N.W. Marine Drive Vancouver, B.C. V6T 1X2	**SPONSOR** **SCIENTIFIC AUTHORITY**	Environment Canada

OBJECTIVE

1. To maintain current awareness of biomass energy technology developments with specific reference to needs and activities of the forest industry in Canada.
2. To coordinate, administer and/or manage ENFOR projects, where appropriate.

DESCRIPTION

In 1979-80, 16 ENFOR projects were managed and; in 1980-81, the number was 20. Two and one-half person years of resources are available in 1981-82 to provide technical liaison for 18 projects, to prepare technical reviews, to procure information through inspection and to transfer information as required.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1979-80	$150,000			$150,000
1980-81	$159,330			$309,330
1981-82	$225,505			$564,835
1982-83	$222,900			

REPORTS

MACKAY G., HUFFMAN D., GRAHAM B., SADDLER J., KRYLA J., Status of Biomass/Energy Conversion Technology - ENFOR Program Review. March 1982

STATUS AND COMMENTS

83/05/04

PROJECT DATA SHEET # 256

TITLE	Bioenergy Program Management	**PROGRAM IDENTIFICATION**	4.3.10 Biomass Energy/Project Management
CONTRACT #	n/a	**DURATION**	April 1981 on
CONTRACTOR	Division of Energy Research & Development National Research Council Montreal Road Ottawa, Ontario K1A OR6	**COST**	$232,000 to date
		SPONSOR	National Research Council
PRINCIPAL INVESTIGATOR	R.P. Overend Tel.: (613) 993-1342 (from April 1983)	**SCIENTIFIC AUTHORITY**	n/a

OBJECTIVE

To manage the incremental projects undertaken through the National Energy Program, specifically to provide technical assessment of the program, monitor progress and provide scientific guidance to research contractors.

DESCRIPTION

When new projects in Bioenergy Research were initiated in 1981 under the auspices of the National Energy Program it was recognized that an augmentation to the resources of the Bioenergy Program Office was necessary. Therefore 2 person-years and $100,000 in the first year were provided to facilitate effective program management of in-house research activities and contract research.

This funding makes it possible for the Bioenergy Program Office to technically assess proposals and reports, and to evaluate technological advancements so as to fulfill the mandate of providing technical advice to the policy staff of Energy, Mines & Resources.

The expected outputs are:
1. Timely identification of technology advancement.
2. Immediate access to current status of all projects.
3. Timely achievement of technology transfer via appropriate media.

FUNDING

FISCAL YEAR	SPONSOR	CONTRACTOR		CUMULATIVE TOTAL
1981-82	$100,000			$100,000
1982-83	$132,000			$232,000
1983-84	$150,000			$382,000

REPORTS

Mechanization of Hybrid Poplar Plantations, Bioenergy Program, NRCC, 1983.
Summary of the Federal Program, April '82 to March '83 Ottawa, Canada, NRCC # 21207, April 1983.
Proceedings of Fourth Bioenergy R&D Seminar, Winnipeg, Manitoba, March 29-31, 1982.
Summary of the Federal Program, April '81 to March '82 Ottawa, Canada, NRCC # 20068, May 1982.

STATUS AND COMMENTS

R.P. Overend was appointed Bioenergy Program Manager as of April 1, 1983.

The mechanization project has reached the testing stage for the harvester/buncher and the front end loader and near prototype completion for other systems. The biofuels project is concentrating on pretreatment problems and chemical engineering aspects associated with scale-up of biological processes to convert biomass to liquid and gaseous fuels. A new project for the in-vitro propagation of hybrid poplar clones is being launched in Spring 1983. 83/04/27

APPENDICES

APPENDIX I

Resource Allocation in Bioenergy Research and Development from 1977 to 1982 inclusive

(expressed as percentage of total annual expenditure)

Program Element	1977	1978	1979	1980	1981	1982
	%	%	%	%	%	%
Resource Assessment	6.9	12.8	8.9	20.3	15.0	10.9
Environmental Effects	-	1.6	5.7	6.4	4.6	4.6
International Participation	-	.8	.6	.4	1.4	0.3
Silviculture	-	-	-	-	-	1.5
Planting/Harvesting/Collecting	-	2.4	5.6	13.1	11.2	9.6
Conversion Technologies	58.2	55.1	51.2	27.9	33.0	42.3
Strategic Studies	-	13.9	7.9	16.7	18.0	19.3
Economic/Technical Assessment	34.9	12.3	16.4	6.4	2.2	3.4
Materials Handling	-	1.2	1.6	6.0	10.6	5.1
Management	-	-	2.1	2.8	3.9	3.0
	100.0	100.1	100.0	100.0	99.9	100.0

Source of Funding of Bioenergy Research & Development in 1982-83

	($K)	($K)
Interdepartmental Panel for Energy Research & Development through (a) Renewables Task		
Agriculture Canada	700.0	
Environment Canada	3850.0	
National Research Council	1012.0	
Energy Mines & Resources	3300.0	8862.0
(b) Liquid Fuels Task		
Agriculture Canada	1655.0	
National Research Council	915.0	
Energy Mines & Resources	1700.0	4270.0
Other Federal Agency Sources:		
Agriculture Canada		200.0
Environment Canada		288.0
Natural Sciences & Engineering Research Council		1141.0
National Research Council		1705.0
Total direct federal funding of Bioenergy R&D		16466.0

APPENDIX II

CLASSIFICATION INDEX

SUB-PROGRAM 4.3.1 BIOMASS RESOURCE ASSESSMENT

4.3.1.1 - Forestry - Mill Wastes

4.3.1.2 - Forestry - Logging Residue

4.3.1.3 - Forestry - Biomass Factors

4.3.1.4 - Forestry - Energy Plantations - Productivity

4.3.1.5 - Agriculture - Animal Residues

4.3.1.6 - Agriculture - Plant Residues

4.3.1.7 - Agriculture - Energy Crops

4.3.1.8 - Peat (not included in program after March 1981)

4.3.1.9 - Algae

SUB-PROGRAM 4.3.2 ENVIRONMENTAL EFFECTS

4.3.2.1 - Forestry - Silvicultural and Harvest Impacts

4.3.2.2 - Forestry - Conversion Technology Impacts

4.3.2.3 - Agricultural - Agricultural and Harvesting Impacts

4.3.2.4 - Agricultural - Conversion Technology Impacts

4.3.2.5 - Peat - Harvesting (not included in program after March 1981)

4.3.2.6 - Peat - Conversion Technology (not included in program after March 1981)

SUB-PROGRAM 4.3.3 INTERNATIONAL PARTICIPATION

4.3.3.1 - International Energy Agency "Short Rotation Forestry for Energy"

4.3.3.2 - International Energy Agency "Biomass Technical Information Service"

SUB-PROGRAM 4.3.4 SILVICULTURE

SUB-PROGRAM 4.3.5 BIOMASS PLANTING, HARVESTING AND COLLECTION TECHNOLOGIES

SUB-PROGRAM 4.3.6 BIOMASS CONVERSION TECHNOLOGIES

4.3.6.1 - Biogas Production

4.3.6.2 - Fermentation to Alcohol

4.3.6.3 - Low Joule Gasification

4.3.6.4 - Medium Joule Gasification

4.3.6.5 - Methanol

4.3.6.6 - Direct Combustion

4.3.6.7 - Char Production

4.3.6.8 - Oil Production - Liquefaction

4.3.6.9 - Chemical Feedstocks e.g. NH_3 (but not including transportation fuels)

4.3.6.10 - Electrical Generation

4.3.6.11 - Pyrolysis

SUB-PROGRAM 4.3.7 BIOENERGY - STRATEGIC STUDIES

4.3.7.1 - Anaerobic Fermentation

4.3.7.2 - Fermentation of Pentoses

4.3.7.3 - Genetic Manipulation of Microbial Strains for Energy Production

4.3.7.4 - Fluidizable Heat Storage

4.3.7.5 - Molecular Models of Photosynthesis

4.3.7.6 - Solar Energy Conversion via Photosynthetic Bacteria

4.3.7.7 - Catalytic Synthesis

4.3.7.8 - Membrane Applications in Gas & Liquid Separations

4.3.7.9 - Biochemical Production of Hydrogen

4.3.7.10 - Oil-Bearing Microbes

4.3.7.11 - Immobilized Cell Techniques for Fuel Production

4.3.7.12 - Cellulase

SUB-PROGRAM 4.3.8 SOCIO-ECONOMIC-TECHNICAL STUDIES

4.3.8.1 - Social Infrastructure

4.3.8.2 - Technology Assessment

4.3.8.3 - Economic Assessment

4.3.8.4 - Information

4.3.8.5 - Legal Studies

SUB-PROGRAM 4.3.9 BIOMASS MATERIALS HANDLING, TRANSPORTATION & PRE-TREATMENT

4.3.9.1 - General

4.3.9.2 - Materials Handling

4.3.9.3 - Transportation

4.3.9.4 - Pre-treatment

SUB-PROGRAM 4.3.10 BIOENERGY PROJECT MANAGEMENT

APPENDIX III

REPORT AVAILABILITY

The reports listed in the project summary section of this publication may be obtained from the organization listed below. A complete listing of all Bioenergy research and development reports available is given in Appendix IV.

The Energy Library, a part of the National Science Library known as the Canada Institute for Scientific and Technical Information (CISTI), is the official repository of all scientific reports produced by or on behalf of the government of Canada. Therefore, two copies of each report of the bioenergy program are supplied to the Energy Library from which they are available through inter-library loans. For information contact:

Energy Library
Canada Institute for Scientific and
Technical Information (CISTI)
National Research Council
Room 29, M-55
Montreal Road
Ottawa, Ontario
K1A 0S2

Phone (613) 993-3861
Telex NRC LIB OTT 053-3115

The ENFOR Secretariat has a limited supply of reports on projects sponsored by Department of the Environment. These reports are available free on request. For information contact:

ENFOR Secretariat
Canadian Forestry Service
Department of Environment
19th Floor
Vincent Massey Building
351 St. Joseph Blvd.
Hull, Québec
K1A 1G5

Phone (613) 997-3409

Agriculture Canada reports in print or on microfiche are available from the **Energy Library** of CISTI. The microfiche reports are distributed for a charge of $2.20/microfiche.

NRC Publications Office supplies priced publications of the bioenergy program. Requests, accompanied by cheque or money order payable to Receiver General of Canada - Credit National Research Council, should be sent to:

Publication, Sales and Distribution
National Research Council
R-88, Montreal Road
Ottawa, Ontario
K1A 0R6

Phone (613) 993-2054 or 993-1996

APPENDIX IV

BIOENERGY R&D REPORTS

Reports are available on loan from the Energy Branch Library Canada Institute for Scientific and Technical Information, National Research Council, Montreal Road, Ottawa, Ontario. K1A 0R6. Reports prefaced with an asterisk are available at nominal cost from NRC Publications, M-58, Montreal Road, Ottawa, Ontario. K1A 0R6.

RESOURCE ASSESSMENT

Neil and Gunter Ltd., A Study of the Potential for Residue/Energy Systems in Eastern Canada Utilizing Wood Residues. Fredericton, N.B., March 1978.

British Columbia Wood Waste Energy Co-ordinating Committee, Hog Fuel Availability in British Columbia. This report is based on a study undertaken by Reid, Collins & Assoc. Ltd., July 1978.

Northern Forest Research Centre, Biomass Productivity of Young AspenStands in Western Canada. Edmonton, Alberta, NFRC Information Report NOR-X-219, January 1980. ENFOR Project P-22.

British Columbia Wood Waste Energy Co-ordinating Committee, Hog FuelAvailability Study - South Coastal Region of B.C. Based on a study performed by Reid, Collins and Associates, Vancouver, B.C., September 1978.

Blais, McNeil, Lussier, Tremblay and Associates, Études sur les volumes de résidus du bois disponibles sur le chantier de coupe et à la scierie pour la production d'énergie. Ste. Foy, Québec, December 1978.

THOMAS J.B., Biomass Inventory of Tolerant Hardwoods. Based on a study performed by Arch Enterprises, Sault Ste. Marie, Ontario, December 1978. ENFOR Project P-21.

WELDWOOD Robert W., Ph.D., P. Eng., Part I: Biomass of Forest Tree Components. Part II: Recovery of Biomass. Part III: Utilization of Biomass. A complete-tree utilization: an analysis of the literature (1970-1978). ENFOR Project P-15.

Blais, McNeil, Lussier, Tremblay and Associates, Volume of Wood Residues for Energy Production at Parent. A summary. November 1979. ENFOR Project P-6.

SMITH Ruth E., LOUCKS Ronald H., R.H. Loucks Oceanology Limited, Assessment of Seaweed Biomass. July 1980.

InterGroup Consulting Economists Limited, Availability and Cost of Forest Biomass in Canada. Winnipeg, Manitoba, March 1982. ENFOR Project P-224(1). Interim Report.

ALEMDAG I.S., Institut forestier national de Petawawa, Service canadien des forêts, Manuel de collecte et de traitement des données pour l'établissement des relations de la biomasse forestière. Chalk River, Ontario. Rapport d'information PI-X-4, 1980. ISSN 0228-0736.

ALEMDAG I.S., Petawawa National Forestry Institute, Canadian Forestry Service, Manual of Data Collection and Processing for the Development of Forest Biomass Relationships. Chalk River, Ontario. Information Report PI-X-4, 1980. ISSN 0706-1854.

HORTON K.W., Horton Forestry Service Ltd., Biomass Yield Tables for Aspen in Ontario. Stouffville, Ontario, March 1981. ENFOR Project P-30(1)

HORTON K.W., Horton Forestry Service Ltd., Biomass Potential of Aspen and White Birch in Ontario. Stouffville, Ontario, March 1981. ENFOR Project P-30(2).

RESOURCE ASSESSMENT (cont'd)

THOMAS J.B., Biomass Inventory of Tolerant Hardwoods in Algoma, Ontario. Ontario, March 1981. ENFOR Project P-182.

SMITH Harry J. and WILLIAMS D.H., University of British Columbia, A Proposal to Develop a Comprehensive Forest Biomass Growth Model. March 1980. ENFOR Project P-64.

KER M.F., Maritime Forest Research Centre, Canadian Forestry Service, Tree Biomass Equations for Ten Major Species in Cumberland County, Nova Scotia. Fredericton, N.B. Information Report M-X-108, 1980. ENFOR Project P-4.

BICKERSTAFF A., WALLACE W.L., EVERT F., Petawawa National Forestry Institute, Growth of Forests in Canada Part 2: A Quantitative Description of the Land Base and the Mean Annual Increment. Chalk River, Ontario 1981. Information Report PI-X-1. ENFOR Project P-16.

LAVIGNE M.B., VAN NOSTRAND R.S., Newfoundland Forest Research Centre, Biomass Equations for Six Tree Species in Central Newfoundland. St. John's, May 1981. Information Report N-X-199. ENFOR Project P-112.

CAMERON D.A., Matcam Forestry Consultants Inc., Biomass Production from the Harvesting of a Tolerant Hardwood Stand in Algoma, Ontario. 1981. ENFOR Project P-152 and P-211.

DANCIK B.P., HEIDT J.D., HIGGINBOTHAM K.O., TITUS S.J., Department of Forest Science, University of Alberta, Development of a Stand Growth Model for Trembling Aspen in the Prairie Provinces of Canada. Edmonton, March 1980. ENFOR Project P-102.

PROCOS D., Technical University of Nova Scotia (TUNS), Agricultural and Other Biomass Wastes as a Local Source of Energy. Nova Scotia, March 1982. Contract No. 09SX;31155-0-2664.

Northland Associates Limited, Pilot Study for the Canada Biomass Inventory. St. John's, Newfoundland, September 1982. ENFOR Project P-242. Interim Report

SINGH T., Northern Forest Research Centre, Biomass Equations for Ten Major Tree Species of the Prairie Provinces. Edmonton, Alberta, 1982. ENFOR Project P-92. (Woodlot Service) Final Report

ENVIRONMENTAL EFFECTS

Saskatchewan Power Corporation, The Social, Environmental and Resource Impact of Wood Gasification on Isolated Northern Communities. ENFOR Project C-8(2).

KIMMINS J.P., DE CANTANZARO J., BINKLEY D., University of British Columbia, Tabular Summary of Data from the Literature on the Biogeochemistry of Temperate Forest Ecosystems. Vancouver, October 1979. ENFOR Project P-8.

Le Groupe Dryade, Evaluation of Potential Impacts of Forest Biomass Harvesting. August 1980. ENFOR Project P-95.

FREEDMAN B., MORASH R. and HANSON A.J., Dalhousie University, Biomass and Nutrient Removals by Conventional and Whole-Tree Clear-Cutting of a Red Spruce-Balsam Fir Stand in Central Nova Scotia. Halifax, Nova Scotia, 1981. ENFOR Project C-40(2) Repring from the Canadian Journal of Forest Research Vol. 11:249-257.

FREEDMAN B., Dalhousie University, Intensive Forest Harvest: A Review of Nutrient Budget Considerations. Halifax, Nova Scotia, 1981. Information Report M-X-121.

FREEDMAN B., DUINKER P.N., BARCLAY H., MORASH R., PRAGER U., Dalhousie University and Institute for Resource and Environment Studies, Forest Biomass and Nutrient Studies in Central Nova Scotia. Halifax, Nova Scotia, 1982. Information Report M-X-134.

PETERSON E.B., LEVSON V.M. and KABZEMS R.D., Northern Forest Research Centre, Upper Limits of Standing Crop Density for Woody Species in the Prairie Provinces. Western Ecological Services, (B.C.) Limited, Sydney, B.C. 1982

SILVICULTURE

FORTIN André J., LAVALLÉE Robert and PICHÉ Yves, Laval University, Forest Utilization for Energy and the Role of Nitrogen Fixation. Ste. Foy, Québec. ENFOR Project P-9.

FORTIN André J., Laval University, Uses of Nitrogen Fixation and Other Root Symbioses for Biomass Production. Ste. Foy, Québec, May 1981. ENFOR Project P-78. (Interim Report)

FORTIN A.J., Université Laval, Uses of Nitrogen Fixation and Other Root Symbioses for Biomass Production. Ste. Foy, Québec, March 1982. ENFOR Project P-198 (P-78). (Interim Report)

HARVESTING AND COLLECTION

Paul H. Jones and Associates Ltd., Energy from Forest Biomass on Vancouver Island. Vancouver, B.C., March 1979.

CHISHOLM B.S., Valley Forest Products Ltd., and VAN RAALTE G.D., Maritimes Forest Research Centre, Biomass Harvesting and Chipping in a Tolerant Hardwood Stand in Central New Brunswick. Fredericton, N.B. Information Report M-X-III, 1980. ENFOR Project P-39.

NAGLE George S., Nawitka Renewable Resource Consultants Ltd., Analysis of Salvage Yarding Systems and Costs in Pacific Coast Forests. Victoria, B.C., October 1980. Information report #BC-X-214 of the Pacific Forest Research Centre. ENFOR Project P-162.

WILTON W.C. and DUFFETT W.P., Abitibi-Price Inc., Whole Tree Chipping for Hogged Fuel in Newfoundland. St. John's, September 1980. Newfoundland Forest Research Centre Information Report N-X-186. ENFOR Project P-115.

WILTON W.C., Northland Associates Ltd., Integrated Logging for Production of Pulpwood and Hog Fuel. March 1981. ENFOR Project P-143.

SHORT C.A., University of New Brunswick, KIPPING J.E., Kipping and Associates Ltd., Mobile Roadside Chipper - Feasibility and Design Concepts. 1982.

Do-Tan Manufacturing Limited, Grapple Attachment Feasibility Study and Design Concepts. 1982.

JASINSKI S.K., Hyd-Mech Engineering Limited, Harvester Buncher - Feasibility Study and Design Concepts. Woodstock, Ontario, March 1982.

SPANJER D.L., David L. Spanjer & Associates, Study and Analysis of Harvesting Systems. Willowdale, Ontario, March 1982. Contract No. 01SX.31155-1-2674-M.

Bowater Newfoundland Limited, Harvesting Forest Biomass as an Alternate Fuel. Corner Brook, Newfoundland, June 1982. DSS Contract No. 10SC.KL001-1-0022. ENFOR Project P-191.

WONG J.Y., Carleton University, Evaluation Study of Soil Strength Measurements. Ottawa, Ontario, June 1982. Contract No. 0SX81-00132.

BIOENERGY R&D REPORTS

CONVERSION TECHNOLOGIES

H.A. Simons (International) Ltd., B.C. Research Hog Fuel Gasifier Scale-Up Project. Vancouver, B.C., December 1977.

British Columbia Wood Waste Energy Coordinating Committee, Hog Fuel Co-generation Study, Quesnel, British Columbia. A summary report based on a study by H.A. Simons (Int'l) Ltd., May 1978.

Institut de recherche de l'hydro Québec (IREQ), Gazefication des résidues de récoltes pour la production d'énergie. Varennes, Québec, 31 mars 1979.

Manitoba Research Council, Evaluation of a Fixed Bed Wood Gasifier Using Chipping Round Wood as Fuel. Winnipeg, Manitoba, April 1979.

Eastern Forest Products Laboratory, Environment, BIOMASS GASIFICATION - Effects of Moisture, Temperature, Pressure and Reactor Design. Report OPX227E. Ottawa, Ontario, 1979.

Eastern Forest Products Laboratory, Environment, A REVIEW OF BIOMASS GASIFICATION - The Role of Catalysis. Report OPX221E. Ottawa, Ontario, 1979.

B.H. Levelton & Associates Ltd., Assessment, Selection and Commissioning of a Small-Scale Research Gasifier. 22 June 1979. ENFOR Project C-2.

Ontario Research Foundation, Rapid Gasification of Wood Waste. 5 July 1979. ENFOR Project C-18.

ADI Limited, Performance Evaluation of Straw Burner, Lyndhurst Farms Limited, Canning, N.S.. Fredericton, N.B., February 1980.

HAWTHORNE H.M., Western Laboratory, N.R.C., The Lubricity of Methanol - A Laboratory Assessment. LTR-WE-10, July 1978.

University of Toronto, A Study on the Rapid Devolatilization/Hydrogenation of Biomass Material. March 1980. ENFOR Project C-24.

Eco-Research Limited, Application of a Fluidized Bed Gasifier to Conversion of Forest Biomass to an Energy Source. ENFOR Project C-68.

DUNCAN Douglas W., B.C. Research, Characterization of Tar Produced During the Gasification of Wood. Vancouver, B.C., April 1981. ENFOR Project C-53.

CALVÉ L, SHIELDS J., Forintek Canada Corporation, Development of Lignin Adhesives. Ottawa, Ontario, March 1982. ENFOR C-209.

HOWARD John, B.C. Research, Supercritical Gas Extraction of Chemicals from Forest Products. Vancouver, B.C., March 1980. ENFOR Project C-51. (Interim Report)

DALVI A., INCO, Study of the Application Fluid Bed Technology to Gasification of Wood. Volume I: Laboratory and Miniplant Tests. Volume II: 100 TPD Prototype Wood Gasification Facility. 30 June 1980. ENFOR Project C-12.

DALVI A., INCO, Fluid Bed Gasification of Lignite. 30 June 1980.
(Not available)

LAWSON A., LAST A.J., Ontario Research Foundation, Methanol as a Fuel Extender for Diesel Engines. December 1980.

ADI Limited, Lameque Peat Boiler Tests for NRC. December 1980.

CONVERSION TECHNOLOGIES (cont'd)

VAN DEN BERG L., Biological Sciences, National Research Council, Methane from Wastes. NRCC 18541. (Available from author)

VAN DEN BERG L., Division des sciences biologiques, Conseil national de recherches, Production de methane à partir des déchets. CNRC 19190. (disponible d'auteur)

COOKE N.E., MOFFAT J.M., ROBILLARD L.A., S.N.C. Group, Study on the Generation of Design Data for Biomass Liquefaction Pilot Plants. Montreal, Québec, April 1981. ENFOR Project C-118.

STEVENS T.G., VAN DEN BERG L., N.R.C., Anaerobic Treatment of Food Processing Wastes Using a Fixed Film Reactor. Reprint of a paper presented at the 1981 Industrial Waste Conference, Purdue University, Lafayette, Indiana, May 1981. (Available from L. van den Berg, Biological Sciences, N.R.C., Sussex Drive, Ottawa, Ontario. K1A OR6)

B.H. Levelton & Associates Ltd., An Evaluation of Wood Waste Conversion Systems 1980. Vancouver, B.C., March 1981. ENFOR Project C-111.

VAN DEN BERG L., KENNEDY K.J., HAMODA M.F., Biological Sciences, National Research Council, Effect of Type of Waste on Performance of Anaerobic Fixed Film and Upflow Sludge Bed Reactors. Ottawa, Ontario. K1A OR6. NRCC 19315. Paper presented at the 1981 Industrial Waste Conference at Purdue University, Lafayette, Indiana, May 1981. (Paper available from authors)

SCOTT D.S., University of Waterloo, The Flash Pyrolysis of Wood in a Bench Scale Fluidized Bed. Waterloo, Ontario, November 1981. ENFOR Project C-28.

HALL Gregory A., Inproheat Industries Ltd., Development of a Small Scale Gasifier for Wood Waste. Vancouver, B.C., March 1982. ENFOR Project C-150.

KENNEDY K.J., VAN DEN BERG L., Biological Sciences, National Research Council, Effects of Temperature and Overloading on the Performance of Anaerobic Fixed Film Reactors. Ottawa, Ontario. K1A OR6. NRCC 19322. Paper presented at the 1981 Industrial Waste Conference at Purdue University, Lafayette, Indiana, May 1981. (Paper available from authors)

BASU S.N., STANGEBY P.C., University of Toronto, A Study on the Rapid Devolatilization/Hydrogenation of Biomass Material, Phase II. Toronto, Ontario, May 1981. ENFOR Project C-98.

MCDONALD Elizabeth C., HOWARD John, B.C. Research, Supercriticat Gas Extraction of Chemicals from Forest Products, Phase II. Vancouver, B.C., October 1981. ENFOR Project C-51.

COOKE N.E, MOFFATT J.M., EVANGELIDI I.G., The SNC Group, Study on the Design and Optimization of Biomass Liquefaction Process Units. Volume I: Technology Report and Pilot Plant Volume II: Industrial Scale Wood Liquefaction Plant. Montreal, Québec, March 1980. ENFOR Project C-69.

PHILP R.J., AZARNIOUCH M.K., Pulp and Paper Research Institute of Canada, Wood Residues as Fuel Sources for Lime Kilns. Pointe Claire, Québec, April 1981. ENFOR Project C-123.

W.M. Newby & Associates Limited, Large Scale Combustion Technology for Steam Production. Niagara Falls, Ontario, November 1980. NRCC 18732 $7.50.

Saskatchewan Power Corporation, Evaluation of Wood Gasifier at Hudson Bay. May 1979. ENFOR Project C-8(1).

CONVERSION TECHNOLOGIES (cont'd)

STONE J.E., MARSHALL H.B., John Stone & Associates Ltd., Analysis of Ethanol Production Potential from Cellulosic Feedstocks. Aylmer, Québec, August 1980.

WEISGERBER G.A., Saskatchewan Power Corportion, Pilot Plant Investigation of the SPC Wood Gasifier at Hudson Bay. Regina, Saskatchewan, June 1980. Final report for ENFOR Project C-29.

HAWTHORNE H.M., LOWE J.T., Wear in Fuel Pumps Pumping Methanol and its Reduction by Vegetable Oil Additives. Vancouver, British Columbia, June 1981.

S.N.C. Inc., Production of Electricity Generation by Wood-Fired Steam Engines for Remote Communities. Montreal, Québec, December 1981. ENFOR Project C-178.

ZUK B., BLAKE J., CRAIG W., COXWORTH E., STRAYER R., Canola Oil as Fuel for Farm Diesel Engines. Saskatoon, Saskatchewan, September 1981. Final Report.

BIRCHER Keith G., SUTHERLAND Russell P., Omnifuel Gasification Systems, Design Study for Wood Gasifier/Engine Test Project. Toronto, Ontario, March 1982.

SADDLER J.N., Forintek Canada Corporation, Conversion of Cellulose to Ethanol Using a Two-Stage Process. Ottawa, Ontario. March 1982. ENFOR Project C-181.

VAN DEN BERG L. and KENNEDY K.J., Effect of Substrate Composition on Methane Production Rates of Downflow Stationary Fixed Film Reactors. National Research Council, Ottawa, Ontario. 1982. NRCC No. 19826.

MACKAY G., HUFFMAN D., GRAHAM B., SADDLER J. and KRYLA J., Forintek Canada Corporation, Status of Biomass Energy Conversion Technology. Ottawa, Ontario. March 1982. ENFOR Program Review.

BACON D.W., DOWNIE J., HSU C.C., RUNCIMAN R. and LARISH G.K., Queen's University, An Annotated Bibliography of Gasifier Modelling. Kingston, Ontario. January 1982. ENFOR Project C-197.

Charles D. Turner & Associates Limited, Feasibility Study n the Conversion of an Oil/Gas Heating Plant at C.F.B. Borden of a Biomass Fuel Plant. Don Mill, Ontario. September 1982. ENFOR Project C-228.

McDONALD E.C., HOWARD J. and BENNETT B., B.C. Research, Chemicals from Forest Products by Supercritical Gas Extraction - Phase III. Vancouver, British Columbia, 1982. ENFOR Project C-51.

EAGER R.L., MATHEWS J.F. and PEPPER J.M., University of Saskatchewan, Production of Liquid Fuels and Chemicals from Lignocellulosics (Aspen) Materials. Saskatoon, Saskatchewan, 1982. ENFOR Project C-48(2).

PROCOS D., BEN-ABDALLAH N., Technical University of Nova-Scotia, Agricultural and Other Biomass Wastes as a Local Source of Energy. March 1982.

McDONALD E.C., HOWARD J., BENNETT B., B.C. Research, Chemicals from Forest Products by Supercritical Gas Extraction. Vancouver, B.C., June 1982. ENFOR Project C-51.

PHILIP R.J. and AZARNIOUCH M.K., PAPRIC, Wood Residues as Fuel Source for Lime Kilns. Pointe Claire, Québec, November 1982. ENFOR Project C-123.

MPB Technologies Inc., A Comparative Study of Laser Spectroscopic Techniques for Analysis of Biomass Gasifier Products. Ste. Anne de Bellevue, Québec. September 1982. ENFOR Project C-240.

BOOCOCK D.G.B. and MACKAY D., University of Toronto, Development of a Process for Conversion of Wood into Liquid Fuel. Toronto, Ontario, December 1982. ENFOR Project C-44. Final Report

CONVERSION TECHNOLOGIES (cont'd)

Lamb-Cargate Industries Limited, Testing, Modification and Evaluation of a Lamb West-Cell Burner/Lime Kiln. Ottawa, Ontario. March 1982. ENFOR Project C-181. Interim Report

MÉNARD H. and ROY C., Sherbrooke University, Characterization of Pyrolytic Oils from Trembling Aspen. Sherbrooke, Québec. ENFOR Project C-256. Interim Report

MURPHY K.L. and TIERNEY D.R., Anaerobic Digester Mixing Studies. Based on a study performed by the International Environmental Consultants. May 1982. Interim Report

EAGER R.L., MATHEWS J.F. and PEPPER J.M., University of Saskatchewan, Production of Liquid Fuels and Chemicals from Lignocellulosic (Aspen) Materials. Saskatoon, Saskatchewan, 1982. ENFOR Project C-48(2). Final Report

WILSON J.J., Imperial Oil Limited, KHACHATOURIANS G.G., INGLEDEW W.M., University of Saskatchewan, Protoplast Fusion in the Yeast, Schwanniomyces alluvius. Mol. Gen. Genetics 186:85, 1982.

WILSON J.J., Imperial Oil Limited, KHACHATOURIANS G.G., INGLEDEW W.M., University of Saskatchewan, Protoplast Fusion in the Yeast, Schwanniomyces alluvius. Fourth Bioenergy R&D Seminar. Winnipeg, 1982.

WILSON J.J., Imperial Oil Limited, INGLEDEW W.M., University of Saskatchewan, Isolation and Characterization of Schwanniomyces alluvius Amylolytic Enzymes. Appl. Envir. Micro. 44:301, 1982.

DHAWALE M.D., INGLEDEW W.M., Improved Method for Detection of Starch Hydrolysis. Appl. Envir. Micro. 44:747, 1982.

WILSON J.J., KHACHATOURIANS G.G., INGLEDEW W.M., Schwanniomyces: SCP and Ethanol from Starch. Biotech. Lett. 4:333, 1982.

DHAWALE M.D., INGLEDEW W.M. (under review), Starch Hydrolysis by Derepressed Mutants of Schwanniomyces castellii.

LO K.V., WHITEHEAD A.J., LIAO P.H. and BULLEY N.R., University of British Columbia, Methane Production from Screened Dairy Manure Using a Fixed-Film Reactor. Vancouver, B.C.

LO K.V., WHITEHEAD A.J., LIAO P.H. and BULLEY N.R., University of British Columbia, The Effect of Solids-Separation Pretreatment on Biogas Production from Dairy Manure. Vancouver, B.C.

Roslyn Park Farm Limited, Demonstration of Anaerobic Digestion and Single Cell Protein Recovery at a Canadian Beef Feedlot. April 23, 1982. Final Report

Lamb-Cargate Industries Ltd., Oil Replacement on a Pulp Mill Lime Kiln Using Hog Fuel in a Lamb Wet-Cell Burner. New Westminster, B.C., March 1983. Final Report ENFOR C-14.

ROY C., MÉNARD H., Université de Sherbrooke, Caractérisation des huiles pyrolytiques provenant du peuplier faux-tremble. Sherbrooke, Québec, février 1983. Projet ENFOR C-256. Rapport final.

KRYLA J.M., Forintek Canada Corporation, Effect of Particle Size on Gross heat of Combustion of Wood. Ottawa, Ontario, March 1983. ENFOR Project C-257.

ADI Limited, Feasibility Assessment of Biogas Generation by Anaerobic Fermentation of Pulp and Paper Wastes. Fredericton, N.B. ENFOR Project C-300.

BIOENERGY R&D REPORTS

FUNDAMENTAL STUDIES

KHAN A.W., TROTTIER T.M., PATEL G.B., MARTIN S.M., Division of Biological Sciences, N.R.C., Nutrient Requirement for the Degradation of Cellulose to Methane by a Mixed Population of Anaerobes. Ottawa, Ontario, 1978. NRCC Report 17367.

PATER G.B., ROTH L.A., VAN DEN BERG L. and CLARK D.S., Characterization of a Strain of Methanospirillum hungatii. NRCC No. 15452.

VAN DEN BERG L., PATEL G.B., CLARK D.S., and LENTZ C.P., Factors Affecting Rate of Methane Formation from Acetic Acid by Enriched Methanogenic Cultures. 1976. NRCC No. 15453.

PATEL G.B. and ROTH L.A., Effect of Sodium Chloride on Growth and Methane Production of Methanogens. 1977. NRCC No. 16041.

KHAN A.W., Anaerobic Degradation of Cellulose by Mixed Culture. 1977. NRCC No. 16335.

PATEL G.B., KHAN A.W. and ROTH L.A, Optimum Levels of Sulphate and Iron for the Cultivation of Pure Cultures of Methanogens in Synthetic Media. 1978. NRCC No. 16602.

PATEL G.B. and ROTH L.A., Acetic Acid and Hydrogen Metabolism During Coculture of an Acetic Acid Producting Bacterium with Methanogenic Bacteria. 1978. NRCC No. 16813.

KHAN A.W. and TROTTIER T.M., Effect of Sulfur-Containing Compounds on Anaerobic Degradation of Cellulose to Methane by Mixed Cultures Obtained from Sewage Sludge. October 1977. NRCC No. 16716.

KHAN A.W., TROTTIER T.M., PATEL G.P. and MARTIN S.M., Nutrient Requirement for the Degradation of Cellulose to Methane by a Mixed Population of Anaerobes. December 1978. NRCC No. 17367.

PATEL G.B., ROTH L.A., SPROTT G.D., Factors Influencing Filament Length of Methanospirillum hungatii. January 1979. NRCC No. 17369.

WANG P.Y., JOHNSON B.F. and SCHNEIDER H., Biological Sciences, N.R.C., Fermentation of D-Xylose by Yeasts Using Glucose Isomerase, in the Medium to Convert D-Xylose to D-Xylulose. Letter 2, 273-278 (1980). NRCC 18377.

WANG P.Y., SHOPSIS C. and SCHNEIDER H., Biological Sciences, N.R.C., Fermentation of Pentose by Yeasts. NRCC No. 18197. (Available from the author)

ABUBAKER M.Y., BERGOUGNOU M.A., TARASUK J.D. and SULLIVAN J.L., University of Western Ontario, Measurement of Local Heat Transfer Coefficients Around a Horizontal Tube in a Shallow Fluidized Bed. London, Ontario.

ABUBAKER M.Y., TARASUK J.D., SULLIVAN J.L. and BERGOUGNOU M.A., University of Western Ontario, Heat Transfer Studies for a New Wood-Burning Baffled Fluidized Bed Furnace and for Fluidizable Heat Storage. London, Ontario.

BERGOUGNOU M.A, University of Western Ontario, Storage and Recovery of Thermal Energy by Fluidizable Beds. London, Ontario.

Université de Sherbrooke, Pyrolyse et gazéification catalytiques des matières lignocellulosiques. Phase I: mai 1979 - mars 1980. Sherbrooke, Québec, mars 1981. Projet ENFOR C-33.

KHAN A.W. and VAN DEN BERG L., Fermentative Conversion of Cellulose to Acetic Acid and Cellulolytic Enzyme Production by a Bacterial Mixed Culture Obtained by Sewage Sludge. Applied and Environmental Microbiology, 1981. NRCC 19323. (Available from the author)

FUNDAMENTAL STUDIES (cont'd)

KHAN A.W. and VAN DEN BERG L., Cellulase Production by the Anaerobic Digestion Process. Biotechnology and Bioengineering Symposium, 1981. NRCC 19820. (Available from the author)

KHAN A.W. and SADDLER J.N., Cellulolytic Enzyme System of Acetivibrio cellulolyticus. Canadian Journal of Microbiology, 1981. NRCC 19016. (Available from the author)

KHAN A.W., MURRAY W.D. and VAN DEN BERG L., Clostridium saccharolyticum sp. nov., a Saccharolytic Species from Sewage Sludge. Intern. J. System. Bacteriology, 1982. NRCC 19895.

KHAN A.W., SADDLER J.N. and MARTIN S.M., Regulation of Cellulase Synthesis in Acetivibrio cellulolyticus. Microbios, 1980. NRCC 18740. (Available from the author)

SADDLER J.N. and KHAN A.W., Cellulase Production by Acetivibrio cellulolyticus. Canadian Journal of Microbiology, 1980. Volume 26, Number 7.

BREUIL C. and PATEL G.B., Viability and Depletion of Cell Constituents of Methanospirillum hungattii GP1 During Starvation. Canadian Journal of Microbioloby, 1980. Volume 26, Number 8. NRCC 18352.

KHAN A.W., SADDLER J.N., PATEL G.B., COLVIN J.R. and MARTIN S.M., Degradation of Cellulose by a Newly Isolated Mesophilic Anaerobe, Bacter[illegible]daceae Family. FEMS Micro. Letters 7, 1980. NRCC 17871.

BREUIL C. and PATEL G.B., Composition of Methanospirillum hungatii GP1 During Growth on Different Media. Canadian Journal of Microbiology, 1980. Volume 26, Number 5.

BREUIL C. and PATEL G.B., Accumulation of an Iodophilic Polysaccharide During Growth of Acetivibrio cellulolyticus on Cellobiose. Arch Microbiol., 1981. NRCC 19386.

BREUIL C. and PATEL G.B., Effect of pH and Oxygen on Growth and Viability of Acetivibrio cellulolyticus. Journal of General Micro., 1981. 125, 41-46.

MARTIN S.M., GLICK B.R. and MARTIN W.G., Factors Affecting the Production of Hydrogenase by Desulfovibrio desulfuricans. Canadian Journal of Microbiology, 1980. Volume 26, Number 10.

PATEL G.B. and AGNEW B.J., A Simple Apparatus for Measuring the Eh of Anaerobic Media. Canadian Journal of Microbiology, 1981. Volume 27, Number 8.

CHUAQUI C.A., LYNN K.R., WILLIAMS R.E., MARTIN S.M., Polymeric Viologens as Electron Donors in Hydrogen Production by Intact Cells of Clostridium pasteurianum, Desulfovibrio desulfuricans, and Rhodospirillum rubrum. Makromol. Chem. 181, 651-656, 1980. NRCC 18008.

GLICK B.R., MARTIN W.G. and MARTIN S.M., Purification and Properties of the Periplasmic Hydrogenase from Desulfovibrio Desulfuricans. Canadian Journal of Microbiology, 1980. Volume 26, Number 10. NRCC 18529.

WILLIAMS R.E., TOYE B.W. and MARTIN S.M., Biologically-Assisted Hydrogen Production. Attempts at Optimizing the Use of Polymeric Viologen Mediators in a Bioreactor Based on the Hydrogenase-Catalyzed Decomposition of Dithionite. NRCC 17947.

SOCIO-ECONOMIC-TECHNICAL STUDIES

B.H. Levelton and Associates Ltd., An Evaluation of Wood-Waste Energy Conversion Systems. Vancouver, B.C., 31 March 1978.

Middleton Associates, Fossil Fuels Savings from the Use of Wood for Space Heating. Toronto, Ontario, April 1978.

InterGroup Consulting Economists Ltd., Liquid Fuels from Renewable Resources: Feasibility Study. 6 volumes. Summary and Conclusions.
Volume A: Demand Studies.
Volume B: Conversion Studies.
Volume C: Forest Studies.
Volume D: Agricultural Studies
Volume E: Municipal Waste Studies.
Winnipeg, Manitoba, May 1978.

Energy Research Laboratories, Energy, Mines and Resources, Efficiency of Wood-Fired Boiler Feasibility Study. Ottawa, Ontario, February 1979. Report ERP/ERL 78-82.

Sandwell and Company, Great lakes Forest Research Centre Boiler Study, Wood Fired Boiler Feasibility Study. Montreal, Québec, 30 November 1978.

Energy Research Laboratories, Energy, Mines and Resources, Performance of Compressed Wood Briquettes in Wood Stoves: A Preliminary Evaluation. Ottawa, Cntario, February 1979. Report ERP/ERL 76-16.

Canadian Wood Energy Institute, Position Paper on Establishing a Data Base Covering Current Use of Wood Energy for Space Heating in Canada. Toronto, Ontario, 15 March 1979.

LAPP H.M., University of Manitoba, A Study of the Feasibility of Using Methane Gas Produced from Animal Waste for Energy Purposes. Winnipeg, Manitoba, March 1979.

Northland Associates Limited, Fuelwood Consumption in Newfoundland. St. John's, Newfoundland, January 1980.

Saskatchewan Power Corportion, The Social, Environmental and Resource Impact of Wood Gasification in Isolated Northern Communities Part I. Regina, Saskatchewan. Based on a study performed by Institute of Northern Studies, University of Saskatchewan, March 1979.

Saskatchewan Power Corporation, Feasibility, Operability and Economic Studies for Energy Sources from Renewable Agricultural Waste and Other Biomass - Interim Report. June 1980. (Not available)

Pulp and Paper Research Institute of Canada, Study on the Recovery of Steam from Thermochemical Pulping by Vapour Recompression, Phase I: Characterization of Vapours from TMP and CTMP Systems. Pointe Claire, Québec, March 1979. Interim Report.

GENFORS Weine, THYR Bjorn, Basic Data for Energy-Balance Evaluation in Forestry. Sweden, Translation by Secretary of State, Ottawa, Ontario, 1979. NRCC 17827 $2.00.

ASH M.J., KNOBLOCK P.C., PETERS N., ESM Energy Systems Management Ltd., Energy Analysis of Energy from the Forest Options. London, Ontario, March 1980. ENFOR Project P-59.

WIKSTEN N.A., PRINS P.G., Arbex Forest Development Company Ltd., Cost Estimates of Forest Biomass Delivered at the Energy Conversion Plant. Ottawa, Ontario, March 1980. ENFOR Project P-19.

SOCIO-ECONOMIC-TECHNICAL STUDIES (cont'd)

Gasohol Inc., Conceptual Design and Cost Estimates for "On-Farm" and Commercial Fuel Alcohol Production. Toronto, Ontario, March 1980. NRCC No. 18231 $3.50.

HAYES R.D., TIMBERS G.E., Engineering and Statistical Research Institute, Alcohol Fuels from Agriculture - A Discussion Paper. Ottawa, Ontario, January 1980. Report 1-165.

MCNAUGHTON Andrew, CUNNINGHAM, S. June, The Biological Transformation of Waste Forest Biomass to Humus for Use as an Agricultural Soil Ammendment. 91491 Canada Limited, Low, Québec. ENFOR Project C-87.

BLACK J.W., BBC Engineering, The Potential for Energy Transfer From a Wood Based Methanol Plant to a Thermomechanical Pulp Mill. Markham, Ontario. NRCC No. 18278 $3.50.

ADI Limited, Performance Monitoring and Thermal Efficiency Determination of a Wood Gas Heating System. Fredericton, N.B. ENFOR Project C-4.

MacCULLUM C., BLACKWELL B.R., TORSUN L., Sandwell and Company Ltd., Cost Benefit Analysis of Systems Using Flue Gas or Steam for Drying of Wood-Waste Feedstocks. Vancouver, B.C., October 1981. ENFOR Project C-96.

McDANIELS T.L., McDaniels Research Ltd., Forest Biomass Energy in British Columbia: Opportunities, Impacts and Constraints. Vancouver, B.C. ENFOR Project P-135.

JONES Keith C., A Review of Energy Requirements to Comminute Woody Biomass. K.C. Jones & Associates Ltd., Ottawa, Ontario, 1981. ENFOR Project P-28.

EGAN J.R., 100 TPD Prototype Wood Gasification Facility: Capital and Operating Cost Estimates. Inco Metals Company, May 1980.

BACON D.W., DOWNIE J., HSU C.C., PETERS J.A., Development of a Technical Basis for Assessing Wood Gasifier Design and Operation. Kingston, Ontario, November 1981. ENFOR Project C-39.

FORINTEK Canada Corporation, Evaluation of Fuels for Operation of a Fixed Bed, Downdraft, Commercial Gasifier. Ottawa, Ontario, December 1981. ENFOR Project C-92.

O'CONNOR D., COTTON T.C., LEVELTON B.H., EDWARDS W.C., B.H. Levelton & Associates Ltd., Wood Waste Fuels Preparation and Handling. Vancouver, B.C., December 1980. ENFOR Project C-95.

BACON D.W., DOWNIE J., HSU C.C., RUNCIMAN R., LARISH G.K., Queen's University, An Annotated Bibliography of Gasifier Modelling. Kingston, Ontario, January 1982. ENFOR Project C-197.

The Coban Institute, Cost of Harvesting Aspen Stands for Energy Production. Edmonton, Alberta. September 1981. ENFOR Project P-193.

MOFFATT J.M. and DHAWAN J.C., The SNC Group, Update on Wood Liquefaction Technology. Montreal, Québec, December 31, 1982. NRC.

ASH M.J. and KNOBLOCH P.C., Energy Consumption on Canadian Woodlands Operations. Study and Report by: Energy Systems Management Limited. Funded by: Energy, Mines and Resources. Done in cooperation with member companies of the Canadian Pulp and Paper Association. June 1982.

B.H. Levelton & Associates Limited, A Review of the Options Available to the Forest Industry for Producing Electricity from Wood Residues. Vancouver, B.C., December 1982. ENFOR Project C-185. Final Report

CHAHAL D.S., Enzymatic Hydrolosis of Cellulose "State-of-the-art". University of Québec, Laval, Québec, November 1982. NRCC 20283.

BIOENERGY R&D REPORTS

MATERIALS HANDLING, TRANSPORTATION AND PRE-TREATMENT

YUNG Thomas Y., W&Y Consultants Kingston Ltd., Development and Small-Scale Demonstration of a Reliable On-Line Monitor for the Continuous Measurement of Feedstock Moisture Content. Kingston, Ontario, April 1980. ENFOR Project C-110.

Carleton University, RF Transmission Line Methods for Feedstock Moisture Content Determination. Ottawa, Ontario, April 1981. ENFOR Project C-154.

ADI Limited, Wood Chips Test with Imbert Company Gasifier, Arnsberg FRG. Fredericton, New Brunswick, May 1980. NRCC No. 18510.

SAYEGH N.N., PARHACS S., AZARNIOUCH M.K., PPRIC, Sandwell Beak Research Group, Evaluation of Infrared Moisture Analyzers for Hog Fuel. Feasibility study of the dewatering of peat using a high velocity, short residence time reactor. March 1981.

Stake Technology ltd., Design, Construction and Testing of a Pilot Scale Continuous Dewatering Device. ENFOR Project C-6.

JONES Keith C., K.C. Jones & Associates Ltd., Field Tests to Develop Energy Saving Wood Comminution Techniques. Ottawa, Ontario, 1981. ENFOR Project P-28.

Intercontinental Engineering Ltd., Study of Hog Fuel Drying Systems.

B.H. Levelton & Associates Ltd., Development of a Moisture Resistant Densified Solid Fuel from Forest Biomass. Vancouver, B.C., December 1981. ENFOR Project C-97.

Avtech Electrosystems Ltd., RF Transmission Line Methods for Feedstock Moisture Content Determination (Phase II). Ottawa, Ontario, October 1981. ENFOR Project C-221.

JONES Keith C., K.C. Jones & Associates, Development and Testing of a Roll Splitter. Ottawa, Ontario, 1982. ENFOR Project P-28.

Lloyd Walker Consulting Limited, Feasibility Study and Design Concepts - Hybrid Poplar Biomass Transportation System. Ottawa, Ontario, April 1982.

Logging Development Corporation, Insertion Planter - Feasibility Study and Design Concepts. Montreal, Québec, 15 April 1982. Contract No. OSX81-00142.

Forintek Canada Corporation, Fuel Value of Stored Forest & Mill Residues - a Literature Study. Ottawa, Ontario, April 1982. ENFOR Project C-220.

HAMILTON D.D., Logging Development Corporation, The Development of Machinery for the Recovery and Preparation of Biomass Feedstocks for Conversion Systems at a Central Full Tree Processing Complex. Montreal, Québec. June 1982. ENFOR Project C-253.

UNLIGIL H., Forintek Canada Corporation, Fuel Value of Stored Forest and Mill Residues. Ottawa, Ontario. May 1982. ENFOR Project C-220(1).

EDWARDS W.C., TAM P., B.H. Levelton & Associates Limited, Forces Exerted on Restraining Strucutres by Hog Fuel Piles. Vancouver, B.C. July 1982. ENFOR Project C-254.

JAGEGH N.N., AZARNIOUCH M.K., Pulp and Paper Research Institute of Canada, Hog Fuel Drying using Vapour Recompression - Phase I. Pointe Claire, Québec. August 1982. ENFOR Project C-214.

MATERIALS HANDLING, TRANSPORTATION AND PRE-TREATMENT (cont'd)

BUNDALLI N., MARTINEZ O., B.C. Research, Bin and Silo Design for Biomass Materials. Vancouver, B.C. July 1982. ENFOR Project C-130.

EDWARDS W.C., B.H. Levelton & Associates Ltd., Status of Biomass Feeder Technology. Vancouver, B.C., December 15, 1981. ENFOR Project C-259.

B.H. Levelton & Associates Ltd., Status of Biomass Feeder Technology. Vancouver, B.C., December 1982. ENFOR Project C-259

INPROHEAT Industries Ltd., Advanced Feedstock Preparation System for Large-Scale Hog Fuel Boilers. Vancouver, B.C., November 1982. ENFOR Project C-149. Final Report.

BIOENERGY R&D REPORTS

INFORMATION

Biomass Energy Institute, Winnipeg, Manitoba
Bio-Joule Vol. 1, 1978 - Vol. 17, 1981.
ENFOR Projects C-15 and E-3.

Hough Stansbury and Associates Ltd., and COATES J.D., Energy From Forest Biomass, Public Awareness Program. Toronto, Ontario, 31 March 1979.

Energy Project, National Research Council, Bioenergy Research and Development Program Review 1978. Ottawa, Ontario, June 1979. NRCC 17671 $2.00.

Projet d'énergie, Conseil national de recherche Canada, Recherche et développement en Bioénergie 1978. Ottawa, Ontario, juin 1979. CNRC 17672 $2.00.

Energy Project Office, National Research Council, Proceedings First Bioenergy R&D Seminar/Compte Rendu Premier Séminaire R&D Bioénergétique. Ottawa, Ontario, March 1979. NRCC 18272 $15.00.

Energy Project, National Research Council, Bioenergy R&D, A Summary of the Program to March 1980. Ottawa, Ontario, July 1980. NRCC No. 18454.

Projet d'énergie, Conseil national de recherche Canada, Recherche et développement en bioénergie - Un sommaire du programme jusqu'à mars 1980. Ottawa, Ontario, juillet 1980. CNRC 19013.

Energy Project, National Research Council, Proceedings Second Bioenergy R&D Seminar/Compte Rendu Deuxième Séminaire R&D Bioénergétique. Ottawa, Ontario, March 1980. NRCC 18273 $15.00.

Energy Project, National Research Council, Proceedings Third Bioenergy R&D Seminar/Compte Rendu Deuxième Séminaire R&D Bioénergétique. Ottawa, Ontario, March 1981. NRCC 19515 $15.00.

Energy Project, National Research Council, Proceedings Fourth Bioenergy R&D Seminar/Compte Rendu Deuxième Séminaire R&D Bioénergétique. Ottawa, Ontario, March 1982. NRCC 20414 $30.00.

Energy Project, National Research Council, Bioenergy R&D, A Summary of the Program to March 1982. Ottawa, Ontario, March 1982. NRCC 20068.

Projet d'énergie, Conseil national de recherche Canada, Recherche et Développement en bioénergie - Un sommaire du programme jusqu'à mars 1982. Ottawa, Ontario, mars 1982. CNRC 20738.

THUNS A., MORRISON B.A., Agriculture Canada, Contract Reports to July 1982. Engineering and Statistical Research Institute. August 1982

APPENDIX V

INDEX OF INVESTIGATORS

Aird, W.R.	176
Bacon, D.W.	150
Beauchamp, E.G.	34
Beeckmans, J.M.	99, 121
Bekker, M.G.	47
Bergougnou, M.A.	115, 117, 122
Billingsley, P.W.	24
Blakeney, K.J.	45
Blouin, J-L.	27
Bone, D.H.	142, 181
Boocock, D.G.B.	112
Brière, D.	47, 57, 178
Bryant, R.H.	134
Bundalli, N.	171, 175
Coulombe, R.	30
Cournoyer, M.	157
Craig, W.	22
Daugulis, A.J.	84, 87
Daynard, T.B.	23
Dhawan, J.C.	154
Doel, R.G.	46, 55
Duck, P.	133
Duckworth, H.E.	92
Duff, S.J.B.	63, 144
Dyer, A.	39
Dykes, B.	20, 21
Eager, R.L.	109
Edamura, R.	184
Elms, R.G.	56
Esplin, G.	94
Eveleigh, D.E.	152

INDEX OF INVESTIGATORS

Fallis, J.	61
Forrester, I.	86
Forsberg, C.W.	127
Fortin, A.	37
Gilles, W.	51
Gravelle, J.	97
Grewe, G.	89
Hall, E.	64
Hall, G.	102
Hanson, A.	29
Hilliard, J.	91
Hopwood, W.A.	9
Horton, K.W.	10
Howard, J.	114, 149
Howell, W.H.	104
Hudgins, R.	100
Huffman, D.R.	189
Ingledew, W.M.	132
Jank, B.E.	64, 65
Jasinski, S.	54
Johnson, K.	145
Kaliaguine	111
Kennedy, K.J.	62, 63, 76
Khan, A.W.	126, 144
Kimmins, J.P.	28
Kropinski, A.M.	79
Kryla, J.M.	105
Kushner, D.J.	143

INDEX OF INVESTIGATORS

Labine, F.	38
Lachance, M-A.	129
Lalonde, M.	40
Landine, R.C.	67
Laughlin, R.J.	161
Lawford, G.R.	80
Leblanc, R.M.	136
Lo, K.V.	71, 74
Lussier, L-J.	165
Lussier, Y.	15
MacCallum, C.	186
Mackay, D.	112
Mackay, J.F.G.	189
MacKenzie, C.R.	145
Maiste, A.	53
Margaritis, A.	83, 140
Martin, S.M.	125
Matthews, J.F.	109
Mayfield, C.I.	139
McDonald, E.	185
Miller, R.C.	135
Moffatt, J.M.	154
Moo-Young, M.	66, 177
Morrissette, D.	73
Murley, S.R.	162
Murray, W.D.	126, 144
Newby, W.	103
Nielson V.	11
Nye, M.	108
Overend, R.P.	190

INDEX OF INVESTIGATORS

Paladino, A.	52
Peill, J.	95, 174
Pepper, J.M.	109
Perreault, A.	18
Peters, R.H.	68
Podruzny, M.F.	75, 144
Procos, D.	19
Robey, H.	180
Robinson, J.B.	32
Robinson, C.W.	130
Rowe, I.	101
Roy, C.	110, 120, 182
Saddler, J.N.	153, 156
Samson, R.J.	63
Sawyer, R.	155
Schneider, H.	128
Scott, D.S.	116, 118
Seligy, V.	131
Sheppard, J.D.	82
Shields, J.K.	77, 78
Shroeter, D.E.	5
Simms, D.A.	31
Smith, P.W.	151
Sourirajan, S.	137
Southwell, H.	108
Strayer, R.C.	106
Tarki, H.	93
Thacher, K.E.	70
Tidwell, T.T.	113

INDEX OF INVESTIGATORS

Unligil, H.	172
van den Berg, L.	62, 63, 64, 69, 76, 144
Veliky, I.	141
Wayman, M.	138
Welsh, F.W.	141
Wilton, W.C.	39
Wong, J.Y.	48
Woodside, R.G.	160
Yamazaki, H.	88
Young, G.B.	6

APPENDIX VI

INDEX OF ORGANIZATIONS

Acres Consulting Services Limited	159
ADI Limited	67
Agropur	68
Alan Moss & Associates Limited	8
B.C. Research	114, 149, 171, 175, 185
Bekker, M.G.	49
Biomass Combustion Limited	95, 174
Biosyn Inc.	97
Blais, McNeil, Lussier & Associates	15
Bondar-Clegg & Company Limited	155
Bowater Newfoundland Limited	162
British Columbia, University of	28, 71, 74, 135
Canadian Boiler Society	103
Canadian Forestry Service	14
Canertech Inc.	92
Carleton University	48, 51, 88
Centre de recherche industrielle du Québec	73
Dalhousie University	29
Darveau, Grenier, Lussier et Associés	165
Dendron Resource Surveys Limited	11, 167
Diversified Research Laboratories Limited	80
Do-Tan Manufacturing Limited	46, 55
Du Pont Canada Inc.	41
Elms Design Incorporated	56
Enersearch	20, 21
ENS BIO Logicals	133
Envirocon Eastern Limited	104
Environment Canada	64
The Environmental Applications Group Limited	31

INDEX OF ORGANIZATIONS

Fallis, John	61
Forest Engineering Research Institute of Canada	47, 57, 178
Forestal International Limited	45
Forintek Canada Corporation	77, 78, 93, 105, 153, 156, 158, 172, 179, 189
Gemini Biochemical Research Limited	86
Le Groupe Dryade Ltée.	27, 30
Guelph, University of	23, 32, 34, 108, 127
Horton Forestry Service Limited	10
Hovey & Associates Limited	50
Hyd-Mech Engineering Limited	54
IMP	69
Inproheat	102
International Environmental Consultants	65
Iotech Corporation Limited	151
Koppernaes, J.D. Engineering Limited	69
Lamb-Cargate Industries Limited	101
Laval University	37, 40, 111
Levelton, B.H. & Associates Limited	73
Manitoba Research Council	70, 91
McLaren Engineers, Planners and Scientists Inc.	72
Ministry of Forests of British Columbia	163
National Research Council Canada	62, 63, 64, 75, 76, 125, 126, 128, 131, 137, 141, 144, 145, 190
Nawitka Renewable Resources Consultants Limited	16
New Brunswick Department of Natural Resources	12
Northland Associates Limited	13
Nova Scotia Department of Lands and Forests	17

INDEX OF ORGANIZATIONS

474706 Ontario Limited	89
The Ontario Paper Company Limited	134
Ontario Research Foundation	82, 161, 180
Ottawa, University of	143
Pampev Inc.	38
Perreault et Associés	18
Pulp and Paper Research Inst.	176
Québec, University of	136
Queen's University	79, 84, 87, 142, 150, 181
Reed, J.D. Machine Limited	53
Resorption Canada Limited	119
Rutgers University	152
Sandwell	186
Saskatchewan Power Corporation	96
Saskatchewan Research Council	22, 109
Saskatchewan, University of	106, 132
Sherbrooke, University of	110, 120, 182
Simons Resource Consultants	166
SNC Incorporated	98, 154
Stake Technology Limited	183
SunRoot Energy Limited	24
Systemhouse	7
Talisman Projects Incorporated	5
Technical University of Nova Scotia	19, 160
Techwest Enterprises Limited	94
Tembec Inc.	81
Thomson, T.M. & Associates Limited	9
Timberland Equipment Limited	52
Toronto, University of	112, 113, 138
Turner, Charles & Associates Limited	107

INDEX OF ORGANIZATIONS

Urgel Delisle & Associates	157
Wastewater Technology Centre	64
Waterloo, University of	66, 100, 116, 118, 130, 139, 177
Wellington Engineering Limited	85, 90
Western Ontario, University of	83, 99, 115, 117, 121, 122, 129, 140
Weston Research Centre	184
Westworth, D.A. and Associates Limited	33
Wilson Trucks	69
Woodland Resource Services Limited	164
Woodlot Service Limited	6